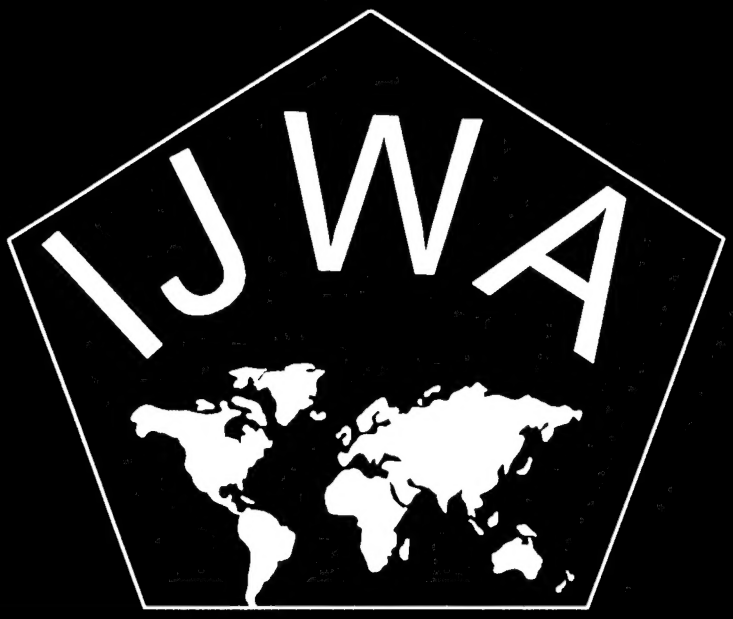
NAVAL POSTGRADUATE SCHOOL
INSTITUTE FOR JOINT WARFARE ANALYSIS

A CONCISE THEORY OF COMBAT



Institute for Joint Warfare Analysis

NPS-IJWA-97-001

A CONCISE THEORY OF COMBAT

Edmund L. DuBois
Wayne P. Hughes, Jr.
Lawrence J. Low

in collaboration with

The Military Conflict Institute

Institute for Joint Warfare Analysis
Naval Postgraduate School
Monterey, California 93943

Naval Postgraduate School
(NPS)

The Naval Postgraduate School mission is to increase the combat effectiveness of U.S. and Allied armed forces and enhance the security of the USA through advanced education and research programs focused on the technical, analytical, and managerial tools needed to confront defense-related challenges.

Institute for Joint Warfare Analysis
(IJWA)

The Institute for Joint Warfare Analysis was founded in 1994 with the mission of addressing the problems of the joint defense arena with the academic disciplines resident at NPS. It sponsors a wide ranging research program, curriculum development focused on joint warfare, and interaction with numerous services and DoD organizations.

TABLE OF CONTENTS

FIGURES

TABLES

PREFACE

This Concise Theory of Military Combat was prepared by members of The Military Conflict Institute (TMCI) as part of a broader program to publish a series of papers to develop public understanding of the nature of military conflict. TMCI is a nonprofit organization dedicated to the advancement of knowledge of military conflict, war, and military combat to reduce the likelihood and dangers of warfare. Its members pursue the goals of TMCI with no compensation other than professional and personal satisfaction.

TMCI was formed in 1979 by a group of military operations research analysts and historians who concluded that then-current models and simulations of war and combat were inadequate and did not reflect a robust understanding of military conflict in its complex dimensions. Since then, TMCI members have prepared and presented research papers dealing with many aspects of military conflict. Over the past five years, emphasis has focused on understanding and summarizing a theory of military combat, and this paper is a result of that focus.

The overall structure adopted by TMCI to organize and present its findings considers military conflict in the context of war and combat. These domains form a general hierarchy and are interrelated, yet separate. As with any taxonomy of human endeavors, the TMCI definition of domains into constituent parts is somewhat arbitrary, and there are exceptions and "fuzzy" boundaries in the structure. There is a question whether war or military conflict should be paramount in the ordering of domains or whether they are relatively equal in importance. War includes many activities other than military conflict, and military conflict exists outside of war. Additionally, there are broad, cross-cutting functions (e.g., command, personnel, intelligence, operations, logistics, civil-military affairs, communications and information, and technology) that apply to each of the major domains in varying degrees with differences in application.

The theories, philosophies, axioms, and principles developed by TMCI and its members are systematic, intellectual structures that explain fundamentals and the way that things work within specified boundaries of the phenomena. They are descriptive and explanatory, but are not necessarily predictive or prescriptive. These theories incorporate quantitative measures and use some mathematical notation to portray complex qualitative relationships, but are not entirely mathematical in nature.

TMCI invites interested readers to send their comments to the authors of this paper. Readers interested in advancing knowledge of military conflict who are willing to work on TMCI products are invited to inquire via:

President of TMCI
12 Fairfield Street
Salem, MA 01970-4808

or

Secretary of TMCI
4827 Yorktown Blvd.
Arlington, VA 22207

INTRODUCTION

What to Expect From This Theory

A Concise Theory of Military Combat propounds a structure intended to relate comprehensively and consistently all elements and activities of every form of organized combat. Our goal is a unified description that is rigorous as to definitions, components, and the dynamics of all combat phenomena.

This theory is explanatory, not prescriptive. Its aim is to describe "what everyone knows is true" about combat. Military professionals and others knowledgeable about military affairs will find no parts of the theory that are new. Our objective is to integrate all parts into a unified whole. Our intention is to be scientific in the sense that art and practice must precede the codification of practice into an organized body of knowledge. The reader will find no attempt to say how to fight better and no recipes for victory. This (or any other) theory is practical only to the extent that knowledge of any subject has practical value. After all, one does not fight or even train with a book in hand.

About Terminology and Definitions

What follows is grounded in the proposition that a theory of combat must be an extension of physical and biological science. When the human factor is excised, the components must behave like physical systems. Our approach is to describe what is added by the presence of human combatants. Definitions and descriptors should link the familiar terms of physical theory to combat theory and vice versa. Here is an example. Combat *force*, meaning a compulsion imposed on an enemy, has been said by some writers to be an analogy to physical force. The theory presented here asserts that combat force is not an analogy but a real phenomenon. We know it is real because, like physical force, its effects can be observed. But its effects are richer than physical force because they act on humans as well as machines. The force imposed by one side upon the other in a battle has not only physical but also mental and spiritual consequences. We know this because we observe not only casualties but fear and demoralization in soldiers subject to intense fire.

To label the compulsion "force," however, would perpetuate a longstanding problem of the terminology of warfare. This theory reserves the term *force* to mean an organized body capable of fighting an enemy. Compulsion, says this theory, derives from combat energy. The energy is converted into combat power which in turn produces observable results. The results are the measure of combat power achieved.

The term *combat power* has itself been used ambiguously to mean both the latent combat energy embodied in a military force and the rate at which the energy is exerted on the battlefield. To make the distinction clear, the theory refers to the latent energy as *combat potential* and says that combat power occurs only during combat. Thus, in a campaign a commander deals with the development, deployment, and sustainment of his force's combat potential. Only when the force engages in combat does he transform potential into combat power that is felt by the enemy.

Development of the Theory

The authors wish to credit the work of The Military Conflict Institute (TMCI) as the basis of this *Concise Theory of Combat*. For more than a decade TMCI's objective has been to advance an understanding of organized warfare in all its aspects. TMCI was founded in 1979 by Dr. Donald S. Marshall, General George Blanchard, and the late Trevor Dupuy. From the outset TMCI has guarded its independence from the armed forces and private institutions alike. TMCI is incorporated as a nonprofit organization, international in scope and open to all points of view.

But the roots of this document lie deeper than TMCI. On 27 September 1977, the Office of Naval Research of the Department of Defense sponsored a conference at Leesburg, Virginia, which expressed the need for a theory of combat to guide and undergird models, simulations, and analyses of warfare. Subsequently, a small group of operations analysts held several meetings in 1979 and 1980 at the Naval Postgraduate School in Monterey, California, at the behest of Professor Michael Sovereign who was then Chairman of the Department of Operations Research. The hope of these gatherings was for a more solid foundation of theory to guide operations analysts in the development of models of combat, including computer simulations and war games. Attendees were operations analysts experienced in quantitative historical study and military operations research, including Herbert Weiss, Lawrence Low, Robert Helmbold, Paul Moose, John Wozencraft, Wayne Hughes, James Taylor and several others from on and off campus.

After the first Working Meeting of TMCI at the Army War College in June 1982, these efforts fused, combining those who emphasized quantitative methods with those who emphasized descriptive methodology. The result is this document, a coalescence of both points of view that can serve as a basis and reference point for combat modeling and as a description of combat for officers who believe that art and practice will be stronger when based on a foundation of theory.

The early meetings of TMCI comprised a diverse set of attendees and presentations. Nineteen working meetings have been recorded and archived by

Doctor Marshall, who maintains TMCI's files and library at his home in Salem, Massachusetts. At the meetings many points of view were represented, discussions were spirited, and cohesion sometimes resulted, but was always ephemeral. A large number of people looked in on TMCI's meetings. Many who did so made valuable contributions but most were impatient to get to their own favorite issues and fell away after a few sessions, especially since TMCI was unfunded and most attendees bore their own expenses. The corporate Army lost interest when it became apparent that TMCI's aims would not solve immediate problems confronting decision makers. To the extent that the other Services were aware of the effort at all, they were similarly indifferent toward work that offered no immediate payoff. Nevertheless, the Army War College and Naval Postgraduate School continued generously to provide space for meetings, as did several other organizations, notably SAIC, Institute for Defense Analysis, SRI International, and Center for Naval Analyses.

By the mid-1980s, it was clear that biannual sessions of a few days could not be sufficiently focused, and so two six-week retreats were arranged, at the Naval Postgraduate School and the University of California at Berkeley. Those sessions were attended by a hard core of TMCI working members. By 1990, the essential material was more or less in hand for this theory, but other sections planned to cover practical applications and modeling were far from complete. The larger work seemed still some years off, so the present authors undertook to assemble the document you are reading. Progress was slow because all of the work was volunteer and in large part unfunded.

Meanwhile, the Naval Postgraduate School had established an Institute for Joint Warfare Analysis to foster independent, scholarly, but utilitarian basic military research and defense analysis. *A Concise Theory of Combat* is one of its first publications.

Withstanding the Test of Time

It is just as well that some twenty years have transpired since the Leesburg Conference. The manifold changes that have occurred since then have provided a breadth of perspective against which to test the robustness of the theory. We have seen:

- A reorientation of tactics and operational plans in the U.S. Armed Forces from combat against the Soviet Union to regional conflict and operations other than war.

- Radical changes in technology, which have led to a new vocabulary of terms such as dominant battlefield awareness, operational maneuver

from the sea, information warfare, command and control warfare, and precision strike.

- Profound organizational realignments that flowed from the Goldwater-Nichols Act. The fallout is manifest in extensive changes to doctrine with added emphasis on joint operations.

Over the same 20 years, changes in military operations research have been nearly as extensive. Analysts now lean more heavily on computer simulations that aim to enhance battlefield realism. War games span the possibilities from simple seminar games to computer-assisted games and distributed interactive simulations. Field exercises using instrumented ranges have expanded in territory covered, and number of forces in play. Computer-based virtual reality reaches far beyond the realism of early aircraft simulators. The mathematics of chaos, complexity, fractals, self-organizing systems, and other new explanations of phenomena may open other doors to understanding warfare.

Yet the changes in military affairs, in science, and in computer technology have required no substantive changes to the theory. In fact, this theory has anticipated many of them:

- Object-oriented programming is consistent with our combat theory's fundamental notion that combat is fought by elements that exist in states and perform functions.

- Computer simulations that attempt to relate several echelons of battlefield activity depend for viability on the proposition of our theory that combat elements and their actions can be aggregated and decomposed within a hierarchy that exhibits congruency throughout every echelon.

- We see recent emphasis on "information warfare," and yet the importance of information gathering, transfer, and processing have long been important features of the theory.

- Emphasis on maneuver versus firepower has re-emerged in contentious contemporary debate. The theory has recognized from the outset that fire and maneuver both make essential contributions to combat power, along with other factors, such as deception, shock, posture, and surprise.

- Suppression and demoralization by firepower, the effect of which was so evident in the Gulf War, were given prominence in the theory a decade ago.

In addition, the theory frames other concepts recognized in a general way but seldom incorporated in specific terms by the operating and analytical worlds:

- There is a difference between battlefield reality and perceptions of reality by all combatants.
- Chance, probability, risk, and other aspects of uncertainty in combat have specific places and weight in combat theory.
- Functions performed by each side (such as command, fire, and maneuver) must be distinguished from processes, in which the results of combat (such as destruction, suppression, demoralization, and motivation) are formed by interaction of the two sides.
- The actions of nature and effects of the environment are given the status of a third party in combat.
- The theory is careful to distinguish combat potential as latent combat energy embodied in a force not in combat, from combat power, which is the rate of delivery and effectiveness of a force's energy directed against the enemy.
- The mission has a top-down vectoring influence on all combatants, and external influences also have an important impact.

The theory parallels current thought, which treats command as both a function and a process, and carries the notion further by specifying command-control to be the process that transforms combat potential into combat power vectored toward the objective, whether that be enemy forces or another focus specified in the mission statement.

About Clarity, Brevity, and Further Study

There will be readers who say the theory is neither clear nor concise. Can't it be reduced to something more easily grasped? Something brief? For the individual who wants an extreme distillation, the six axioms and associated definitions found in Chapter 1 are a minimal expression of the necessary basis for a general theory. How well the axioms will serve by themselves is another question. Newton's three laws of motion may have been sufficient for several centuries of progress, but scientists and engineers spent lifetimes understanding their implications and applying them usefully. Living-systems theory says that the whole hierarchy of plant and animal life can be described as matter, energy, and information and the transformation of one into another. To apply that theory to living systems in a useful way is something else again.

As for brevity, are you really surprised that a description of combat cannot fit on a one-page executive briefing? War is a highly complicated human endeavor, and combat is its pinnacle. It should be no surprise that a description of combat takes more than a few pages, and that understanding it entails close study.

Finally, the reader should bear three things in mind: first, comprehension comes from grasping the theory all of a piece. If it doesn't all hang together, then it has failed. Second, if this work has merit, then testing, rework, and extension are to be expected. Third, an understanding of the theory will allow the reader to know combat only in the way a spectator in the stands knows football. To play in a position on the team requires more than understanding the theory.

Lawrence J. Low Edmund L. Dubois Wayne P. Hughes, Jr.

DEFINITIONS

Listed below are definitions of terms as they are used in this document.

Action - an act performed by a single or aggregated element to change the state of one or more other elements, its own state, or both.

Activity - see **combat activity**.

Agent element - see **element**.

Attribute - a qualitative or quantitative modifier of a combat element. Attributes are of three kinds:

> **Spatial conditions**: the time-space characteristics of elements, including location, spatial orientation, and motion.
>
> **Physical properties**: descriptors of elements that can be stated and measured in physical terms, such as dimensions, weight, shape, and configuration.
>
> **Qualities**: nonphysical, subjective descriptors of elements, such as those relating to motivation, reliability, and durability. Qualities are the only attributes of cognitive elements.

Available combat potential - the latent capacity of a force to achieve useful results in combat with its existing organization, training, equipment, support, motivation, and leadership.

Chance event - an event that occurs without discernible human intention or cause.

Cognitive element - see **element**.

Cognitive entropy - the ratio of what is not known about the combat situation to complete knowledge of the combat situation; the measure of unknown relative to knowable, hence a measure of confusion, disorder, and uncertainty in the combat arena.

Combat activity - one or more combat elements each taking an action that impacts one or more other combat elements, themselves, or both, thereby producing a result that changes the attributes of the impacted elements. The term "combat activity" is synonymous with the term "combat process" except that in the process, results are expressed in terms of the primary combat

processes rather than in general terms. See also **combat process**, **primary combat process**, and **element**.

Combat arena - the three-dimensional location where combat takes place, including locations remote from the main combat action from which actions are carried out that directly affect combat.

Combat environment - the geophysical space and features of the combat arena.

Combat friction - unproductive energy expended on any wasteful result that occurs in a force when an agent element of the force carries out an action impacting an object element. In the aggregate, combat friction at any time is the summation of wasteful results occurring at that time from many elemental actions at the lowest level of combat.

Combat function - an action taken by one or more elements of either side in combat to achieve an intended result. See **primary combat function**.

Combat mission - an objective to be achieved or a task to be performed in combat, together with the purpose of achieving the objective or performing the task. The objective or task is stated explicitly, but the purpose is sometimes implied.

Combat outcome - the actual end results that accrue as the final states of all elements of all parties in combat when combat has been concluded.

Combat output - the cumulative results (measured as the new states of elements of both sides and the combat environment) of combat power acting over time on the combat situation. Combat output is the time integral of combat power. At the end of combat, combat output equates to combat outcome.

Combat power - the realized capability of a force at any instant of time to achieve results in combat in furtherance of a particular mission against a specific enemy force in a specific combat environment.

Combat process - one or more combat elements each taking an action that impacts one or more other combat elements, themselves, or both, thereby producing a result that changes the attributes of the impacted elements. Each element taking its action is an "agent element" and each element being impacted is an "object element," including the agent element if it impacts itself. Both the agent elements and the object elements may be from either or both sides in combat and/or from the combat environment. The only difference between the terms "combat process" and "combat activity" is that the results from activity are expressed in general terms, whereas the results of process are expressed in terms

of the primary combat processes. See also **combat activity, primary combat process,** and **element.**

Combat result - the changed state that occurs in a single or aggregated element from an elemental or aggregated combat activity.

Combat situation - the totality of the states of both sides and of the combat environment at any point of time during combat.

Designed combat potential - the precombat, latent designed capacity of a force to achieve useful results in combat when organized, trained, equipped, supported, and led according to the force design against a design threat. See also **available combat potential.**

Element - a material or intangible thing of any kind, whether animate or inanimate, that exists in combat and can change the state of another element or itself. The following are subordinate categories of elements:

- **Agent element** - an element that performs an action impacting an object element, itself, or both.
- **Object element** - an element that is impacted by the action of an agent element, thereby having its attributes changed.
- **Cognitive element** - (a) an element with cognitive capability; (b) the product of cognition.
- **Physical element** - an element that has weight and physical dimensions.

External context of combat - everything outside the combat arena that has any influence whatsoever, no matter how indirectly, on what is done by either side during combat; this includes all manner of persons, material things, documents, communication sources, political activity, strategic directives, military forces, and the like.

Internal context of combat - the military forces of the two adversarial parties in combat, together with their mental and physical states, and the combat environment.

Military combat - purposeful, controlled violence carried out by direct means of deadly force between opponents, each attempting to carry out a mission, the achievement of which has value to that side and the achievement of which is opposed in some way by the other side.

Military conflict - an antagonistic state between two or more parties in which military forces and weaponry of each of the parties are used or are available for use and use is intended if needed.

Military force - any body of persons that combines for the purpose of waging or threatening to wage aggressive or defensive military conflict with respect to any other body of persons.

Object element - see **element**.

Physical element - see **element**.

Primary combat function - a generic category of like actions taken by elements of either adversary in combat to achieve an intended result. The complete set of primary combat functions is defined to encompass all functions occurring in combat, so that any single combat function will fall under one or another of the primary combat functions.

Primary combat process - combat activity of any kind that produces a common composite result. The complete set of primary combat processes is defined to encompass all combat activity, and thus all combat results, so that any single combat activity will produce results that fit under one or more of the primary combat processes.

Result - see **combat result**.

State - the condition of existence at a point in time of a single or aggregated element, as determined by its cognitive and physical attributes, including its spatial condition.

Uncertainty - a state of doubt about the combat situation, including the outcome of combat.

Vector - used as a verb: to direct the actions of a force toward a specified mission or goal:

- used as a noun: directed actions that are in accord with a specified mission or goal.

Chapter 1

AN OVERVIEW OF THE THEORY

Military combat is a subset of the broader category of military conflict, which in turn is a subset of human conflict in general. As we use the term, military combat is defined as purposeful, controlled violence carried out by means of deadly force between opponents, each attempting to carry out a mission, the achievement of which has value to that side and denial of which has value to the other side. Wars of course involve deadly force, as do campaigns within wars, but it is only in combat that deadly force is directly and actively applied against the enemy. Combat is the active agent of warfare, the crucible in which war aims are decided.

We include within combat's boundaries the preparatory steps taken by each side immediately before active use of deadly force and the disengagement actions before interaction between the two sides ceases. The phrase "use of deadly force" encompasses the threat of deadly force when it has an effect on combat. We do not bound the scope of combat by the kinds of weapons employed nor by the size of forces or geographical area. Intercontinental delivery of cruise missiles and ICBMs is a combat action on a grand scale. Contiguity of mission is the best determinant of what constitutes combat.

Military combat cannot be treated apart from the campaign and war of which it is a part, and so we include within our purview the external context that forms the boundary conditions for combat and affects its course. Before combat commences and while it proceeds, combat activity is influenced by the direction, impetus, and constraints imposed by the external context, and combat results feed back their influence upon the external context.

As foundation for the theory, we have narrowed a larger list of possible axioms of combat to the following six:

Axiom 1 Military combat involves deadly interaction between military forces.

Axiom 2 In combat each side seeks to achieve a goal, called its mission, which has perceived value.

Axiom 3 Combat potential is embodied in military forces.

Axiom 4 The commander of each side activates combat potential to create combat power in furtherance of the mission.

Axiom 5 Domination of the opposing military force is the ultimate means of accomplishing a mission.

Axiom 6 Uncertainty is inherent in combat.

Mission is the governing factor that vectors activities in warfare, translating purpose into intended action throughout the hierarchical command structure. At every echelon, the mission is meant to be responsive to the echelon above, and to the extent this is so and the missions are properly understood, there is powerful vectoring from top to bottom of the entire force toward its war aims. To the extent the hierarchy of missions is unclear, inconsistent, ambiguous, or misunderstood, vectoring is weakened.

Values underlie the purposes of war, and the purposes of campaigns and combat. At every echelon a value is attached to the outcome of each mission. At the termination of any mission, the value achieved is weighed against the broader picture—never a simple "win-or-lose" analysis. Associated with these values are the costs in attempting to achieve the mission. The value after mission termination is rarely the same as the value before the mission commenced; the very pursuit of the mission has itself caused a dynamic change in the situation, and the cost may have been excessive—or lower than anticipated. This purpose-value-mission-outcome-cost relationship extends through every echelon of warfare and, as with congruity of mission, congruity of purposes and values facilitates commonality of war effort. Every soldier and sailor will have some sense of purpose and value to himself or herself that corresponds—although obviously differing in particulars—to the sense of purpose and value of the theater commander and the civil authorities.

Viewed from the bottom up, combat comprises myriads of things that have attributes and carry out a variety of actions. All activity in combat can be described in terms of these three basic, independent components:

elements
attributes of elements, and
actions taken by elements.

These three components exist in minute detail, and they exist also as combinations of elements with combinations of attributes carrying out combinations of actions in ever larger agglomerations up to the highest levels of combat. Working in reverse, one can disaggregate the combinations of combat activity into smaller combinations of elements, with their attributes, performing lesser actions, and so on down to the most elemental level. Viewing combat from the top down, we see aggregated elements formed into the traditional units of military forces carrying out aggregate actions in the form of fires, maneuvers, searches, screens, deceptions, maintenance, and so forth. But in all cases, these

traditional units and actions exist as combinations built up from elements, attributes and actions at the lowest level.

The component *element* is any material or intangible thing, animate or inanimate, that exists in combat which can act to change the state of another element or itself. This includes obvious physical entities such as guns, persons, ships, and aircraft, but also less obvious objects such as trees, hills, seastate, wind, rain, and sunlight. Elements exist singly and as aggregated elements of related single elements. A rifle and a truck are single elements. A squad armed with rifles is an aggregated element. A truck with driver carrying a load of ammunition is an aggregated element.

The component *action* is an act performed by a single or aggregated element with the intent of changing the state of one or more other elements, its own state, or both. Elements and actions are of two kinds: physical and cognitive. The only elements that are cognitive are humans, who have thoughts and emotions; but humans are also physical elements, since they have weight and size. The only actions that are cognitive are ones taken by humans that derive from mental capacity. A tank firing a round performs a physical action. The decision by the tank gunner to fire the round is a cognitive action. Cognitive elements and actions, however, do not exhibit the property of aggregation that applies to physical elements and actions. This is because the thoughts of a group of humans cannot be combined into a single aggregated element that functions as if it had a single mind. This is not to say a well-functioning unit or staff does not generate thoughts that are so closely coordinated that they have the appearance of coming from a single mind.

The component *attribute* is a quantitative or qualitative descriptor of an element. Attributes include spatial conditions (location, orientation, and motion), physical properties (characteristics that can be physically measured, such as size, weight, and capacity), and qualities (nonphysical descriptors, such as reliability, manpower intensiveness, and clarity of orders).

At every moment of time, the combination of a single or aggregated element and its attributes is the state of that element. Every person, rifle, hill, river, ship, squadron, and force has a present state, but that will change during combat because of the actions taken by itself, by friendly elements, by enemy elements, and by environmental elements.

At the lowest level, an element performing an action will impact one or more other elements and usually also itself. The element taking the action is the "agent element" and the one being acted on is the "object element." An agent element's action alters the object element's attributes in some way, and thus changes the state of the object element. We designate the element-action-element triad,

together with its results, a *combat activity*. Combat is made up of countless numbers of such elemental activities, some involving single elements impacting single elements but more often single elements impacting multiple elements, including the agent element itself.

As with elements and actions, combat activities have the property of aggregation-disaggregation. Thus we see aggregated elements (a ship and crew, for instance) taking an aggregated action (firing a salvo) against an enemy aggregated element (a fortified position or an ammunition dump). Those who wage combat see and experience the aggregated level, but in all cases it is at the elemental micro level that every action and every result in combat begins. The overall structure of combat derives from the primary structure of elements, attributes, and actions.

Considering all categories of aggregated forces and activities, we can construct a generalized functional cross section of combat at any fixed moment. The cross section includes the states of the two opposing forces and the shared geophysical combat environment, as well as the external contexts that impinge on each side. This fixed-time snapshot of combat is universal: it pertains to every form of combat at every echelon, high or low, and pertains to forces operating on land, in the air, at sea, or in any combination. For any one echelon of combat—say combat involving battalion-size forces on both sides—the fixed-time snapshot is subsumed within combat involving larger (say brigade-size) forces and in turn the battalion-size fixed-time cross section subsumes combat involving subordinate (company-level) forces at that moment. Each fixed-time cross section is structurally like all others at higher and lower echelons. Moreover, the types of forces and types of activities of the two opposing sides are structurally identical with each other, and both sides share the combat environment in common. The structure applies even though one side is attacking and the other defending, for example, this mirror imaging of *type* forces and *type* activities between the two sides does not mean equality between the two sides as to number and capability of forces and activities. There is never equality. The congruent nesting of type forces and activities from the lowest to the highest echelon and across all forms of combat illustrates a universal characteristic: military combat is structured as a nested hierarchy of forces and activity with functional repetition of the pattern throughout the hierarchy.

Each side prosecutes its effort through its own combat functions. A *combat function* is a category of like actions taken by force elements; the complete set of combat functions is each commander's bag of tricks, and each side in general has the same kinds of functions (though not with the same capabilities) and employs them to achieve results intended to support its mission. As both sides carry out their functions, the combat activity causes three-sided interactions that create

combat processes. It is through these combat processes that actual results are determined in the form of altered states of force elements.

We define a *combat process* as combat activity of any kind that produces a common generic result. The distinction between combat functions and combat processes is that functions are actions oriented to results *intended* to be achieved by each side, whereas processes are oriented to results *actually* achieved in the give and take of combat. Each side unilaterally applies combat energy to perform its functions to fulfill its mission, but the opponent has a say in the matter and tries, by performing other functions, to thwart the other side's efforts and achieve its own mission. In addition, the combat environment can affect each side. From this three-way interaction comes a set of processes that are reflected in the actual results achieved by each side. The results, seen as the new states of each side's force elements, are the new combat truth that pertains to both sides, although neither side ever fully knows what that combat truth is.

Granting there could be an extremely large number of combat processes, each differing in some small degree from the next, we have settled on a small list of *primary combat processes* that, by definition, encompass the totality of combat activity. Every single element-action-element activity at the lowest level and every aggregated element-action-element activity will contribute to, and thereby fit into, one or more of these primary combat processes, as determined by the results actually achieved. In the normal case, any one activity will involve several processes, including those that affect the acting element itself. The processes fall into two categories: those that impact only enemy force elements, which we designate *externally directed processes* and those that impact only own force elements, designated *internally directed processes*. The primary combat processes are:

Externally Directed	**Internally Directed**
Demoralization	Motivation
Destruction (and damage)	Command-control
Suppression	Information acquisition
Neutralization	Communication
Disruption	Movement
Deception	Protection
	Sustainment

Combat processes, like the elements and actions that are part of those processes, exhibit the property of aggregation-disaggregation. For example, elemental processes of destruction, suppression, and protection at the lowest level are blended into aggregated processes of destruction, suppression, and protection at the higher levels. Since combat processes relate to results obtained, the labels

used for them are descriptive of combat results rather than combat actions such as fire and maneuver.

Within the fixed-time cross section of combat—which itself remains time invariant—all forces and actions of both sides, along with the external contexts and geophysical environment, are in continuous flux. In the time continuum, there is a sequence of these cross sections, differing as to particulars of the situation from one instant to the next and ending in the final outcome of combat. The differing particulars are the new states and it is the processes that bring these about.

The dynamic aspects of the theory of combat rest on the concept of combat power. Combat power, like gravity, cannot be seen, but combat commanders and everyone else subject to it senses what it is. As we use the term, it is the agent by which all results are obtained in combat. We define **combat power** as *the realized capability of a force at any instant of time to achieve results in furtherance of a particular mission against a specific enemy force in a specific combat environment.* Combat power is the action agent by which forces seek to translate the purpose of conducting combat into a desired outcome. Energy in the form of combat functions is applied by each side to its own forces to fulfill its mission and simultaneously to the enemy force to eliminate his opposition. The *realized* capability that each side is able to achieve in the two-sided clash of actions is the combat power that side has managed to produce. Combat power is an instantaneous function (that is, a rate) which, acting over time leads to cumulative results (cumulative changes of state). We use the term *combat output* to refer to the accumulations.

Combat power is derived from the basic element-action-element activities described earlier, and therefore inherits and expands upon characteristics from that structure. Thus combat power:

> Is, most fundamentally, determined by the combination of the actions of a force and the interactions with the opposing force and the combat environment, rather than by the unilateral actions of the force. Because of this, the results of combat power are not necessarily the favorable results planned by each side, but instead are the *actual* results that occur in the light of actions by *both* sides exerting combat power, each seeking to further its own ends.
>
> Is granular in nature. Combat power exists as minute grains or "quanta" derived from the countless individual element-action-element activities at the lowest level of combat. Participants in combat, however, do not see these grains as such; instead, they observe the effects in aggregated form that appears as a continuous flow of power.

Directly impacts elements, not actions. Combat power affects the states of own force and enemy force elements, both physical and cognitive, and elements of the combat environment. Actions are impacted only indirectly through changes of state of elements carrying out actions.

Has a vector-like nature. Combat power is directed to achieve the mission, and thus operates as if vectored by the mission.

Acts as a flow. Combat power is the capacity to achieve results at an instant of time, and therefore operates as the time rate of change of states of elements.

Exhibits the property of aggregation-disaggregation. The elemental bits of combat power can be aggregated into clusters of combat power.

Exists only while combat is in progress. Before combat commences and after it terminates, the capacity to achieve results exists as combat potential.

A *commander* in combat is an individual who causes his forces to take actions that are vectored by the commander in furtherance of the mission. There is a hierarchy of commanders in every force, from the officer in tactical command down to a pilot who flies his aircraft, an individual soldier who commands only himself and his rifle, an operator of a radar who scans it and reports contacts, or a sailor who steers a ship, each doing so in conformance with an explicit or implicit task assigned. The vectoring (the order or command) is temporal (when to act), spatial (where to act), and functional (what action to perform), done to achieve a purpose that may be explicit or implicit. We say a commander activates his forces to create combat power from available combat potential. Insofar as the theory is concerned, the key to recognizing the commander at every echelon is not based on lawful, organizational, or even doctrinal authority and responsibility, but identification of the individual at that echelon who receives and acts on a mission or task and causes forces to take actions (perform functions) to fulfill it.

Combat potential is the latent capacity to achieve results in combat. The development of combat potential begins when raw manpower is recruited and weapons are acquired, and development continues, for the particular force involved, until combat begins. At this point, combat potential is converted into combat power; then, after combat ends, unexpended capacity reverts to combat potential. The combat potential available to a commander when he engages in combat is often less than he would wish because of shortages in manning and equipping and deficiencies in morale and training, but the situation at the time circumscribes what he has to draw on.

A commander, through the command function, begins to convert the latent energy of combat potential to the active energy of combat power by the many steps he takes preparatory to the active phase of combat, such as acquiring intelligence, issuing orders, positioning forces, and exhorting his troops. Once active fighting commences, combat power is determined by the combination of the commander's actions and the interactions with the enemy and the environment. In addition, there are other factors that a commander can only partly control in exerting combat power. On the negative side, the actions of his force will be degraded by wasted energy arising as combat friction in the countless interactions among own-force elements. On the favorable side, to the extent the units are suitably organized and operated as a balanced combined arms force, he can benefit from synergism from mutual support and reinforcement. The commander also may benefit from strong force integrity and cohesion, or, under adverse circumstances, his force could be subject to catastrophic loss of cohesion. Over and above such particular factors, there is a powerful positive influence toward self-regeneration embodied in military units in combat. Under extreme life-threatening stresses and in the face of adversity and disorder, some military units exhibit strong adaptability for survival and reconstituting combat capability.

The set of primary combat processes is inclusive of every kind of result occurring in combat. Through the property of aggregation, we can in principle lump together all the destruction results and all the suppression results and so on for all the other processes, from whatever cause and in whatever sector and over whatever period of time. Our current state of knowledge, however, does not permit us to do this quantitatively beyond crude estimations.

The external processes directly alter the states of enemy elements and thus act to remove enemy resistance to the mission. The internal processes are equally essential to advance the mission and to support the external processes. Some processes operate only on cognitive elements. The internal process of motivation and the counterpart external process of demoralization clearly do so. The command-control process encompasses not only the cognitive decision-making that stems from each person in the chain of command, but also the lesser decisions that every individual in combat makes. The command-control process is so ubiquitous that essentially all action in combat originates by it, except for acts of nature. The command-control process is, in turn, fully dependent on the information acquisition process to take sensible actions.

A brief example may serve to clarify how processes work. A scouting patrol observes (the information acquisition process) an enemy force assembling. Through several steps of the communication process, the information reaches the combat commander. He weighs the information and his options and decides on a course of action (all of this the command-control process). Through the

communication process, his order reaches an artillery battalion commander, who directs a salvo to be fired. On a hand signal from a sergeant (further communication process), soldiers make the decision to yank the lanyards of their howitzers (command-control process in response to the sergeant's signal), firing the guns. When the artillery rounds land in the target area, enemy soldiers are killed and wounded and trucks destroyed and damaged (the destruction process); other enemy personnel cease their actions and take cover (suppression); still others are frightened and run away (demoralization); and the enemy unit's assembly preparations are delayed (disruption). The illustration is a simplification; many additional processes would be occurring at every stage.

The sixth axiom states that uncertainty is inherent in combat. Uncertainty imbues every participant with doubt about the present situation, about what will happen next, and even about what has already happened. Combat is not deterministic, yet experienced commanders and others tested in battle learn to read the partial patterns and forecast future events with enough accuracy to determine the likely direction combat will take. Some succeed at this far better than others, but in all cases it is experience that fills the gaps of uncertainty, and when experience is lacking, training, doctrine, and good sense compensate. Good commanders sense how much they need to know about the situation, and because time is precious they act as soon as enough pieces of a pattern are in place. They proceed not on the certainties but on the probabilities, fully aware that unforeseen events may occur and ramify unpredictably; and they convey their orders with conviction despite the uncertainties.

Within this gray world of incomplete, ambiguous, often biased, partially erroneous information and disinformation, the principal task of every combat commander is to direct the actions to apply energy through combat functions (fire, maneuver, force protection, and so forth) that will manifest themselves as propitious distribution of combat power, vectored in time and space to fulfill the mission.

Combat power exists in the form of minute quanta-like contributions created by countless element-action-element activities at the lowest level. Each of these leads to a change in the attributes of one or more object elements, and thus a new state of those elements. It is at that moment and at the location of the object element that an elemental contribution to combat power is created by the side initiating the activity. The object elements may be physical or cognitive or both, and may be an enemy element or a friendly one (or may be the element performing the action). In the usual case, there will be more than one object element and more than one kind of state change, and therefore more than one process contributing to the elemental bit of combat power.

At any instant of time, these micro-level contributions of each side's combat power can be aggregated spatially over a small area of the combat arena. Over time, the aggregated combat power in that area will wax and wane as combat activities amplify or die down in intensity. If both sides' elements are creating combat power in the area, there will be a separate aggregation for each side's combat power contributions. The combat power aggregations in such small areas can, in principle, be extended to map the combat power for each side over the entire combat arena at any moment, and such a mapping could, in principle, be made for successive time intervals, manifesting itself as a shifting flow of spatially distributed combat power for each side over the duration of combat.

Although the results of combat power are real, when seen in their full complexity there is no known way of representing combat power's full effects quantitatively, and this theory does not advance one. Assuredly the aggregation of combat power cannot be done by any linear summing. Attempts to depict the capabilities of forces have been limited for the most part to firepower's effects, and even simulations have failed to combine such disparate factors as movement, suppression, protection, and deception, or the even more difficult factors such as motivation and demoralization. Complicating this picture further is the relationship of combat power to mission. Combat results that do not go fully in the direction of the commander's vector (that is, fully support the mission) should not be added in the same degree as those that do.

Yet, despite the imprecision, good commanders in combat cope with the uncertainties and accomplish the equivalent of effectively aggregating combat power and distributing and vectoring it to achieve their mission, or give a good account in the attempt. The empirical methods they use have been tried and tested in battle and the lessons set down in doctrinal and tactical manuals, and in broader language in the principles of war. Much of the process is an art, but more than just art and intuition underlies successful command in combat.

Combat is normally episodic. The constantly shifting distribution of combat power for the two sides creates a flow that includes crescendos and lulls. Information is the commodity that controls the peaks and valleys. The flow of information, both as to rapidity and quality, is a crucial aspect in the task of distributing combat power. The side that has the shorter cycle time to acquire, communicate, weigh, act on, and reacquire information has a significant advantage. Similarly, the side that brings the greater accuracy and completeness to the information it acquires has a clear advantage, and likewise, the side that has the faster reaction time in translating decisions into responses has an advantage. These precepts are general; the reality that information and reaction cycle times are continually blended rather than discrete does not minimize their importance.

Throughout combat every participant observes and interprets events as trends, and makes decisions based on his projection of the future. The high value of combat outcome compels such continuing assessment of where the action is leading. It is, however, the *perceptions* of trends that individuals act on, not the reality. At all times every individual, from commanders down to privates, seamen, and airmen, seeks to improve his future situation by reinforcing favorable trends and altering those he sees as unfavorable. Determining an opportune time for action based on perceived trend projection is an art learned from experience and training.

Commanders must be sensitive to culmination points where the course of battle has shifted for the better or worse, taking into account the time lag between when events were observed and when corrective action can be effected. To miss a critical shift or react too late can have a magnified adverse effect. As noted in the U.S. Army 1986 manual on operations, "commanders must understand that in battle, men and units are more likely to fail catastrophically than gradually."

Combat is perhaps the most complex of all human endeavors. The nature of combat, with its peaks and lulls, its constantly shifting combat power, its uncertainties, and with all its participants subject to great hazard and stress, follows no repeatable pattern that allows for predictability in detail. Despite this, experienced commanders and trained forces find ways to successfully apply combat power and achieve missions. Where many throw up their hands at the complexity and chaos of combat, the ones called on to wage battles make a creditable showing. In the same vein, where some disparage as hopeless an attempt to explain the intricacies of combat, we have at least tried. If nothing else, this is a beginning.

Chapter 2

AXIOMS OF COMBAT

2.1 THE AXIOMS

A foundation of any theory rests on a set of axioms. Axioms are self-evident statements asserted as indisputable facts. We have sought to keep the set of axioms underlying this theory of combat to the absolute minimum, and we believe the important tenets of our theory should and can be traceable to these few axioms.

Axiom 1 Military combat involves deadly interaction between military forces.

A military force is defined as a set of elements that are activated for the purpose of engaging in combat. Deadly interaction includes the direct use of deadly means and the threat of using deadly means. Insofar as nonlethal weapons may be used, they are always backed up by deadly means should the latter be needed.

Axiom 2 In combat each side seeks to achieve a goal, called its mission, which has perceived value.

The mission of a force is the specific task assigned it by higher authority or presumed by the commander of the force based on guidance from higher authority. Combat is not undertaken for its own sake in isolation from other activities; it is conducted as a purposeful activity within the broader goals of entities external to combat.

Axiom 3 Combat potential is embodied in military forces.

Combat potential is the latent capacity of a military force to achieve results in combat.

Axiom 4 The commander on each side in combat activates combat potential to create combat power in furtherance of the mission.

Combat power is the realized capability of a military force at any instant of time to achieve results in combat.

Axiom 5 Domination of the opposing military force is the ultimate means of accomplishing a mission.

Domination is the result of imposing the will of one force on the opposing force through all the interactions of combat, especially those affecting the will and spirit.

Axiom 6 Uncertainty is inherent in combat.

Uncertainty is a state of doubt about the combat situation, including its outcome. Uncertainty is distinguished from chance, which concerns unpredictable events that happen without discernible human or other cause.

2.2 PRINCIPLES OF WAR

The principles of war are empirical precepts formulated as guides to the conduct of war and combat. Versions of principles have been set forth by many writers and by official military organizations. The versions differ in detail as to the number of principles and wording, yet there is remarkable similarity. In effect the principles represent wisdom developed over many years by those who have engaged in battles—the distilled lessons learned from successes and failures.

The principles by themselves do not constitute a theory of combat, but they do represent broad, prescriptive counsel to commanders, and as such the theory ought to be consistent with them.

The following is one version of the principles of war, taken from the 1993 issue of the U.S. Army Field Manual 100-5, *Operations*. (The manual includes additional discussion of each principle, which we have omitted here.)

Principle of the Objective - Direct every military operation toward a clearly defined, decisive, and attainable objective.

Principle of the Offensive - Seize, retain, and exploit the initiative.

Principle of Mass - Mass the effects of overwhelming combat power at the decisive place and time.

Principle of Economy of Force - Allocate minimum essential combat power to secondary efforts.

Principle of Maneuver - Place the enemy in a position of disadvantage through the flexible application of combat power.

Principle of Unity of Command - For every objective, ensure unity of effort.

Principle of Security - Never permit the enemy to acquire an unexpected advantage.

Principle of Surprise - Strike the enemy at a time or place, or in a manner, for which he is unprepared.

Principle of Simplicity - Prepare clear, uncomplicated plans and clear, concise orders to ensure thorough understanding.

The Army manual on operations adds discussion of three concepts critical to campaigns and major operations. Since these also apply in some degree to combat, we include them here in greatly abbreviated form.

Concept of the Center of Gravity - Operations should concentrate against those enemy components that are particularly vital, thereby unbalancing the entire enemy structure and producing a cascading deterioration in cohesion and effectiveness that may result in complete failure or will leave the enemy vulnerable to further damage.

Concept of Lines of Operation - A line of operation is the directional orientation of a force in relation to the enemy; it is the linkage between a force's objective and its bases of operation. A single line of operation is preferable to multiple lines of operation when available resources are limited, but when resources are adequate, multiple lines of operation can disperse the enemy's efforts. Operating on interior lines (operations that diverge from a central point) benefits a weaker force, whereas operating on exterior lines (operations that converge on the enemy from more than one direction) can benefit a stronger force by offering the opportunity to encircle and annihilate a weaker opponent.

Concept of Culminating Points - Unless an offensive operation is decisively successful, a culminating point will be reached sooner or later where the strength of the attacker no longer significantly exceeds that of the defender. The art of attack is to achieve decisive objectives before a culminating point is reached; the art of defense is to hasten the culmination point, recognize its advent, and be prepared to go over to the offense when it arrives.

Chapter 3

MILITARY COMBAT IN THE SPECTRUM OF CONFLICT

Human conflicts of many kinds occur throughout the world. Within the broad spectrum of these conflicts, our concern in this document is narrowed to those that involve military conflict, and within this still vast category, the subject is narrowed to warfare, and then further narrowed to the subset of warfare called military combat.

3.1 THE SPECTRUM OF MILITARY CONFLICT

3.1.1 Warfare in the Spectrum of Conflict

Every animate species engages when necessary in conflict with others of its kind and with other species. Most of this arises from the primal need to survive and the urge for procreation to continue the species. The human species appears unique in its ability and willingness to carry conflict to a different order of purpose (whether a higher or lower order is left to others to ponder). Whereas animals fight other animals because of instinct driven by genes, humans plan and deliberately set out to achieve domination over other humans for many purposes using lethal weapons of ever greater efficiency. Warfare is where this characteristic is brought to its ultimate extension, and combat is the locus within war where the killing is carried out.

Whether or not the waging of war and combat is an innate characteristic of humans is not addressed in this work. Warfare is accepted and legally sanctioned in human society, at least for defensive purposes. And since the history of the species has demonstrated that wars have arisen time and again despite attempts to end them, warfare, and combat as its cutting edge, are important subjects for study.

3.1.2 Military Conflict

By the term *military conflict* we mean an antagonistic situation between two or more parties in which military forces and weaponry of each of the parties are used or are available for use and use is implied if needed. The term *military forces* means not only formally constituted armed forces, but any body of persons that combines to wage or threaten aggressive or defensive action vis-à-vis another

group. Thus paramilitary units that may be created without a formal tie to a recognized political entity are military forces that can engage in military conflict, often but not always localized and limited in scope and sometimes carried out under covert or overt sponsorship of a nation. Similarly, counterinsurgency and counterintelligence forces engaged in defense of a political entity are military forces within our meaning. In the more general case, military forces are responsive to nation states and are formally organized by those states into units with weapons and uniforms. And in the more general case, these forces may engage in military conflict in the form of wars, campaigns, battles, engagements, sieges, blockades, and also in forms of military conflict short of outright hostilities, such as shows of force, policing, and peacekeeping.

3.1.3 The Spectrum of Military Conflict

In illustrating the scope of military conflict we can say at the outset that the boundary of what is included cannot be defined by the line between peace and war, since many forms of military conflict occur during periods not considered times of war.

Figure 1 portrays the spectrum of human conflict and, as a subset, the spectrum of military conflict. Two aspects are shown: the levels of violence and the geographical extent. The levels of violence blend and overlap without clear distinction of one from another. Terrorism and sabotage, for example, can range from civilian person-to-person and group-to-group conflicts to international and ethnic conflicts. The geographical extent of conflicts similarly can stretch from localized areas to near-global scope. The second World War was violent conflict waged over much of the globe for several years; the United States attack against Libya in 1986 was violent conflict confined to a small geographical area for a short time.

3.1.4 Strategy and Tactics

The magnitude and geographical extent of military conflict are sometimes distinguished by the terms strategic level and tactical level. These terms are relative and can be misleading when applied to levels of military conflict. In the common meaning, strategy and strategic level refer to the broad, overall concepts and planning for a military conflict, whereas tactics and tactical level refer to the more detailed implementation measures in response to the strategy. A strategy is a plan, with a specifically expressed goal, to execute national or other political policies. Strategic level is therefore usually associated with national authorities and theater-level commands. Most of what takes place in combat is generally considered the tactical level. Recently another term has been

added to distinguish military activity at the level between strategic and tactical. This is called the operational level.

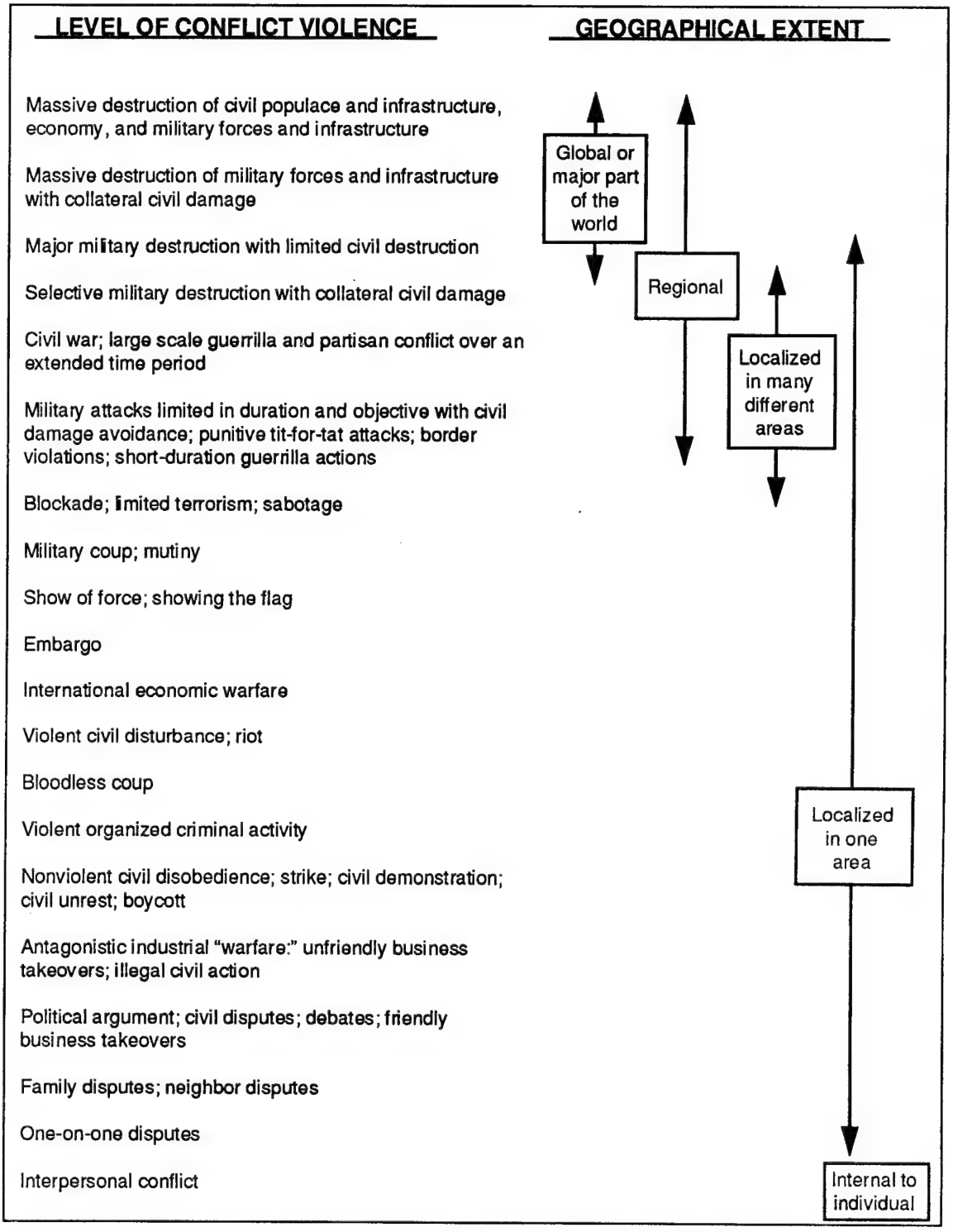


Figure 1. Spectrum of Human Conflict

Yet in contrast to these common uses of the terms, there are frequent references to the strategy of a small part of a military conflict or the strategy used in conducting a single battle. And certainly at each echelon in warfare, a commander has the equivalent of his strategy for conducting operations at that echelon, even though he may not use that term. Because of this variability in meaning, we have not used the labels strategy and tactics as hard and fast distinctions for levels of military conflict. In regard to the operational level of warfare, we prefer the term *campaign* because of its wider usage over many years. Campaigns and operations (or operational art) both refer to the activities conducted to effect a strategy (in the common use of that term), their product being the positioning, maneuvering and sustaining of forces that occurs prior to—and also includes—active combat.

3.1.5 Military Combat within the Totality of Conflict

Figure 2 depicts the place of military combat within the totality of human conflict. War is the principal context within which combat occurs (but not the only context, as combat can occur in the absence of formal warfare). *War* means, in the broadest sense, all the adversarial activities of two (or more) hostile parties to a military conflict. This includes political, economic, and diplomatic actions conducted during the conflict together with actions carried out by military forces. Within wars there can be one or more campaigns, normally of shorter duration and involving a smaller set of forces than are engaged in the war. *Campaign* means the coordinated movement, positioning, and preparation of forces to attain a specified objective, which is responsive to a broader war objective. The campaign may involve a series of stages carried out sequentially or in parallel, and it ends when the objective is achieved or is deemed

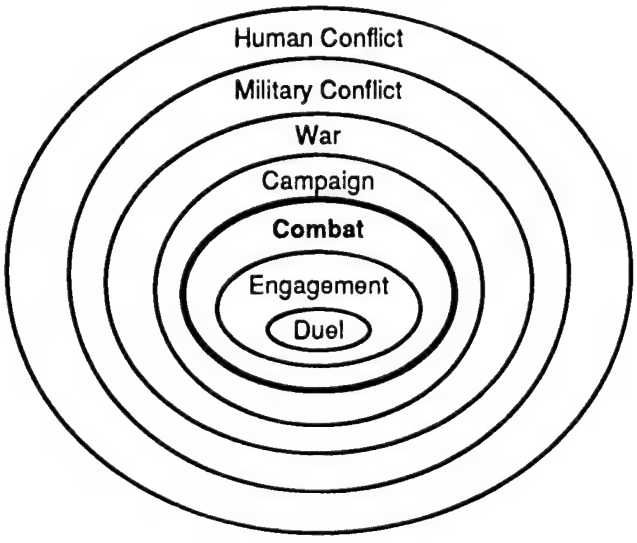


Figure 2. Combat in Relation to Other Forms of Conflict

unattainable. A campaign ordinarily leads to and includes one or more combat situations or threats of combat (the definition of combat is presented below).

Within a particular combat there will be one or more *engagements*, which can take place simultaneously or be separated in time. An engagement is localized, heightened activity during combat that involves intense use of deadly force between the opposing sides. There is no clear-cut boundary that separates an engagement from other activity during combat; the only distinction is that of heightened action in a localized space over a relatively brief time span. *Firefight* is a synonym for engagement. Within engagements there will normally be many shorter spasms of fighting between two entities—individuals, small units, armored vehicles, aircraft, ships—which we call *duels* for lack of a more concise label.

The combination of duels, engagements, combat, and campaigns comprises a continuum of war activity. Within this continuum, events are episodic rather than continuous. There is not an unbroken flow of duels one after the other, nor of engagements, combat, or campaigns.

The term battle is commonly used in a context that equates to our term combat yet sometimes is broader in scope and sometimes approximates our engagement. Because of this spread of meanings, we have not used battle to designate a specific category of military conflict.

3.2 MILITARY COMBAT

3.2.1 Defining Military Combat

We define military combat as *purposeful, controlled violence carried out by direct means of deadly force between opponents, each attempting to carry out a mission, the achievement of which has value to that side and the achievement of which is opposed in some degree by the other side.* Military combat is the active agent—the cutting edge—of warfare. It is the means for achieving war aims through domination of the enemy. There could be a war without casualties, but there cannot be a war without a test of wills, and combat or its threat is where the testing culminates. There also could be stand-alone combat in isolation from the broader scope of war. These circumstances—stand-alone combat and a war without casualties—are aberrant cases. Although our focus has been on the more usual cases where opposing forces use force as necessary to achieve missions within the context of campaigns and war, our findings will apply to aberrant cases as well.

We include within our definition the threat of deadly force in addition to its actual use. Admittedly this may add a degree of fuzziness. A situation in which

force is threatened but not used is an unusual case, though it has occurred in history. We include such a case within our definition only where the initial intent by both sides was to employ deadly force and preparations were made to those ends, even though the intent was later changed by one side before deadly force was brought to bear. We exclude the case where one side from the outset chooses not to oppose the enemy (and cannot be forced into the contest); and we exclude the case where one side absents itself from the scene, leaving the other party to carry out its mission unopposed.

Throughout, the word *combat* by itself is used as a noun or adjective to mean the totality of activity that is included within our definition of the term. The words *a combat* and *the combat* are used as nouns to refer to a particular combat from beginning to end.

3.2.2 When Combat Begins and Ends

Our definition of combat includes a beginning, an active phase, and an ending. The active phase starts when violent means are employed by either side against the opponent. The beginning phase includes the preparatory actions immediately preceding the active phase after a decision has been made by either side to proceed with combat. These include such actions as developing plans and disseminating orders, positioning forces and supplies, setting up protective measures, scouting and other intelligence gathering, and mentally preparing troops. In some cases (an ambush, for instance, or a submarine stalking and executing a surprise attack against an enemy warship) one side has virtually no time to make preparations; under our definition combat has begun when the other side sets up the ambush or begins the stalking. In cases where neither side has time to prepare, combat begins with the active phase. The end of combat is marked by the cessation of interaction by both sides—especially the use of violent means—and the immediate repositioning and reconstitution of forces in accordance with the situation. One side may have gotten its dose of fighting and be on the run, but combat does not end until its opponent has ceased to pursue. It is clear from this discussion that establishing the boundary as to precisely when any particular combat starts and when it ends is to some extent a matter of choice.

Military combat is normally episodic. From the beginning of the active phase until its end there will usually be periods of intense fighting separated by periods of lower activity during which forces regroup to engage in the next confrontation. Insofar as the reduced activity is merely a pause in the on-going action to achieve a mission, it does not constitute a termination of combat within our definition.

3.2.3 The Magnitude of Combat

No firm boundary can be established as to the magnitude of forces, the geographical area, or the time duration that is encompassed within the definition of combat. On the smaller side we can consider combat involving only squad- and platoon-size forces, or two ships or aircraft in extended but isolated actions against each other. On the larger side we can include division- and corps-size air-land-amphibious forces, large naval fleets, and massive air assaults. Contiguity of mission is the governing factor more than size or duration. All the forces of each side that are engaged in fulfilling the mission of their side are the forces participating in the combat, whether or not they actually shoot or are in harm's way. Forces spatially remote from the main combat arena, such as stand-off surveillance aircraft or space-based communications satellites are included when they directly support the mission. The three-day Battle of Gettysburg includes a number of separate instances of combat, as does the Battle of the Somme in 1916 and the Battle of the Bulge in 1944. The Battle of Marathon between Greeks and Persians in 490 BC and the naval Battle of Savo Island in 1942 are single instances of combat.

We likewise establish no bound as to kind of weapon. Any weapon that is potentially lethal or incapacitating is a candidate. Weapons can range from fists, knives and clubs to thermonuclear and biological weapons. The geographical extent and the nature of combat environment are similarly not limited. Combat can occur on land, in the air, at and under the sea, in space, and in any combination of these environments, and it can be confined to a small area or range over a broad expanse in three dimensions.

3.3 THE CONTEXT OF COMBAT

3.3.1 The Internal Context

The internal context of combat is simply all the personnel and materiel of the two opposing sides plus the geophysical environment in which combat is waged. Included with these are also their physical, psychological, cultural and mental characteristics. The quantity and quality of weaponry are included, and also the mission, the doctrinal and tactical training, and the esprit de corps of troops. Every combatant carries layers upon layers of influence with him into combat, from his genetic makeup and what his teachers taught him to the bonding with his foxhole buddy and the faith he places in his commanding officer. These are all part of the internal context. The geophysical environment includes weather conditions, man-made infrastructure, and natural topographical and oceanographic features. Noncombatants, commercial aircraft,

merchant shipping, fishing boats, and the like present within the combat area are part of the context, and some may be the object of attacks. In short, the internal context of combat encompasses all features, animate and inanimate, physical and cognitive, natural and man-made, that exist in the combat arena.

3.3.2 The External Context

In describing combat as the cutting edge of warfare with a discrete beginning and end (granting some looseness as to starting and ending points), we do not mean to isolate combat from the military conflict of which it is part. At all times, from beginning to end, combat and all combatants are affected by the broader context in which combat is set, and what happens in combat feeds back to affect that broader context. War is not suspended while awaiting the outcome of a combat action; other war actions proceed.

Despite its role as the point where crucial actions are decided, combat is always subservient to the wider perspective of the campaign and the war, and beyond that to the higher political interests and to the populace at large. The external context can impose constraints on the conduct of combat as well as strong impetus. Societal culture and the attitude of the folks back home can be powerful influences on individuals, collectively and individually. This broader context affects the purpose, values, and mission that guide each combat, not only at its start but throughout its duration; and the results of combat are fed back as influences on the campaign and the war.

3.3.3 Combat as the Crucible for Decisions

Granting the obvious influences of the external context, it is nevertheless in the crucible of combat that campaigns can become successful and wars can be brought to a favorable end, militarily at least. And granting that in warfare, the time spent and number of persons engaging in combat are a small fraction of the total, it is in combat that critical events are made to happen.

Of all human endeavors, combat is perhaps the most intense and trying for its participants. It forces each to put his life and that of his opponent in jeopardy and dictates that many on each side must give up their lives for a sometimes remote, abstract cause. For every combatant the sacrifices are of the highest, but each senses the stakes also are high and often critical. While not every single combat will have a decisive outcome, it appears that the high-risk, high-stakes nature of combat sets it apart as the crucible where decisions in war are settled. This establishes the importance of examining combat and attempting to explain it as carefully, comprehensively, and scientifically as possible.

Chapter 4

MISSIONS AND OUTCOMES

Axiom 2 states that each side in combat seeks to achieve a goal—its mission—which has perceived value. Mission is a pervasive factor that spurs and harnesses combat activity, both stimulating and constraining the action. It acts to bridge the purpose of combat to the outcome. As such it constitutes the primary means for guiding combat in accordance with the grander designs of wars and campaigns.

4.1 TOP DOWN CONTROL

Mission is a top-down controlling factor which acts through the hierarchical structure of command. The mission given to the highest theater-level echelon becomes the basis for missions assigned to the next echelon, and so on down to the lowest units, each echelon being more circumscribed as to the time and space covered. At the lowest echelons, missions become verbal directions to individuals.

To the extent that the top-down hierarchy of missions is consistent and is comprehended as intended, there is powerful vectoring of an entire force toward the outcome sought by the top of the chain of command. Understanding of the broad purposes of the war effort at all levels serves to foster these conditions. To the extent that missions become muddled, misinterpreted, or evaded, or war purposes are not understood, the vectors' magnitude and direction lose their strength and sharpness.

4.2 THE MISSION

A combat mission consists of two parts: an objective to be achieved (or task to be performed) and the purpose of achieving the objective (or performing the task). The objective is always stated explicitly, although sometimes in broad terms (and sometimes, in the case of a poorly expressed objective, ambiguously). The purpose is often left to be inferred by subordinate commanders.

In its broader sense, mission expresses the end state of affairs to be achieved during the course of combat—the outcome. In contrast, the statement of mission promulgated in a combat order is often phrased as the actions (usually expressed

as tasks) to be accomplished to achieve the outcome, not the outcome itself. In this case the directed actions or tasks serve to imply the outcome, provided they are sufficiently clear. A combat mission statement will normally be a single sentence, but implicit in that brevity will be a vast array of specific actions that the force understands must be taken. Doctrine, training and experience serve to fill in matters not stated, and beyond that, missions are further buttressed by implied national values, goals, and cultural aims. The simple mission of "taking the hill" is understood by all involved as implying many contributing actions for reasons that reach beyond the local situation and for values that, vague as they may be to some, justify the effort and danger. When commanders and individuals cease to see a mission in light of these underlying purposes and values, the mission no longer exerts its directing control over combat, and force effectiveness begins to disintegrate.

Missions are usually received as orders from the next higher command echelon, but they can also be inferred by a commander from his understanding of the policies, goals and intentions of the higher commander and of the entire war effort. In any case the combat commander normally will translate the assigned or assumed mission into a more specific mission statement of the objectives to be attained by his force. The degree of latitude allowed a commander in assuming a mission not explicitly directed from above or in departing from the specifics of an assigned mission will be influenced by what is permissible in doctrine and the personalities of higher and lower commanders. Any combat mission that differs from what was intended by higher echelons risks perturbing the overall control of the war effort—a circumstance that is not necessarily bad if the combat commander has a better appreciation of the local situation and of the context of his combat action within the larger picture.

If the dynamics of the combat situation are altered sufficiently from the initial conditions, the mission itself may be modified in the midst of combat, or if events outside the combat arena change substantially, higher command may direct a new mission. The revised mission, together with revised orders to subordinate units, then supersedes the original mission as the vector guiding combat. In extreme cases, if the cost of continuing becomes excessive, mission abandonment and disengagement or capitulation may be forced.

4.3 RELATIONSHIPS AMONG PURPOSE, VALUE, MISSION, OUTCOME, AND COST

Values underlie the purposes of war, and the derivative purposes of every combat will likewise have values associated with attaining those purposes. In the end, it is the values that will govern the human and material resource costs expended to achieve the purposes, and hence to fulfill the mission. The

relationships among purpose, value, mission, outcome, and cost extend through the hierarchy from top to bottom. The values associated with purposes and missions at the highest echelons are infused as values at lower echelons down to the individual. Compatibility and commonality in the value system throughout the force reinforce the common effort. Nevertheless, values and costs as seen by infantrymen and sailors with their lives at risk are different in particulars from values and costs seen by high level commanders.

The hierarchical relationships among purpose, value, mission, outcome, and cost are illustrated in Figure 3. There can be other conflict levels in addition to the three shown. The purposes, with associated values, at the campaign level flow from those at the war level. At each level, missions derive from the purposes and values at that level and ultimately lead to outcomes that have values associated with them. The values associated with purposes are the *a priori* values of the outcomes intended, together with the expected costs, whereas the values associated with outcomes are the *a posteriori* values after resources have actually been expended—after the costs have been counted and weighed in light of what was achieved and of anticipated future events.

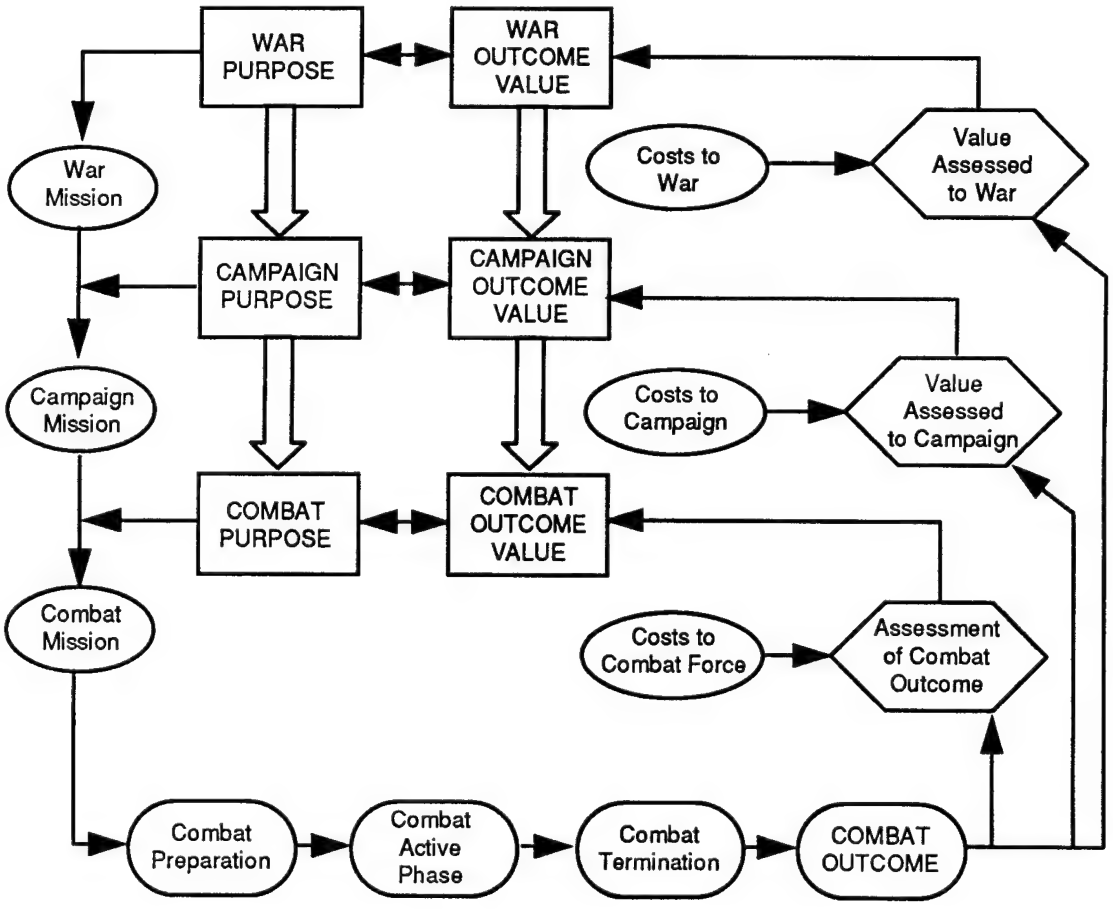


Figure 3. The Hierarchy of Purpose, Value, Mission, Outcome, and Cost

The outcome of any single combat, the gains as well as the costs , contributes to the on-going campaign in which the combat is embedded. More remotely, the outcome adds to the war effort. At each level—combat, campaign, and war—the combat outcome is weighed against the post-combat value at that level. The outcome of combat is shared by both sides of the conflict, but the purposes, values, missions, and assessments are unique to each side.

4.4 OUTCOME ASSESSMENT

In assessing the outcome of a combat just concluded, a combat commander and his superiors will address how closely the outcome fitted his mission, but they will also weigh the value of the outcome in relation to the value of the combat's purpose. They may consider the costs as worth the outcome, or the costs as questionable from the point of view of his own force yet acceptable because of the outcome's contribution to the war effort, or the costs as unacceptable from any point of view. At the campaign level, the outcome of this combat and of all other combat outcomes (as well as noncombat actions) are viewed collectively and the whole is periodically weighed against the purposes and values as seen at that level. The same pattern repeats through all higher levels.

Moreover, the identical pattern of purpose, value, mission, outcome, and cost assessment is also repeated at every lower echelon within the combat force from subordinate commanders down to individuals. At the lowest echelons the assessments are informal or only in the minds of individuals. Thus the pattern of purpose, value, mission, and outcome assessment is constant from the highest to the lowest levels of war.

In no sense can a valid combat assessment by either side be expressed in such simple terms as "win," "lose," or "draw." Combat assessment is never merely a body count or compilation of material destroyed, although these are among many factors to be weighed. It is a complex evaluation seen from different perspectives by many parties. The evaluation is affected by the perceived friendly force situation, the perceived enemy situation and also by the perception of the enemy's perception. The possible course of future events must be considered—the outcome of one battle becomes part of the initial conditions of the next. Uncertainty is an inevitable component of the assessment, and must be taken into account.

Any assessment has only transitory standing—subsequent events in the campaign and war may convert what initially seemed a favorable combat outcome into, in retrospect, an unfavorable one. In addition, a favorable outcome to one side does not necessarily equate to an unfavorable outcome for the other side. For example, one force could successfully execute its mission of "taking the

hill by 1200 hours" while the opposing force was successfully fulfilling its mission of "delaying enemy occupation of the hill until 1100 hours." And even though both sides attained their mission in this example, either or both could have had an adverse outcome if the cost outweighed the value. Combat is not a zero-sum game where one side's fortune always equals the other's misfortune.

To reiterate an earlier point, the outcome being assessed is shared by the opponent, and obviously the impact of the outcome upon the enemy is a major part of the assessment on both sides. As will be discussed in more detail later, it is outcome *as perceived* by the various parties on both sides that is being weighed, and obviously, faulty perceptions about the outcome will lead to faulty assessments.

Assessment does not wait on the conclusion of combat. As combat action unfolds, combat commanders, their subordinates, and their superiors make periodic estimates of the situation and of progress toward mission attainment. Assessment of results during combat enables refinement and redirection of battle activity. Purpose and value continue to be critical determinants, and the balancing of value against cost as combat proceeds is one of the most difficult matters all combatants face—but especially those in command.

4.5 SUMMARY

The mission hierarchy in its broadest sense is the principal means to vector a force toward the desired goals of warfare. It provides control from the top down through every echelon of the military force to all individuals. At every echelon up and down the chain of command, the mission of that echelon derives from the mission of the next higher echelon. Linked with each mission is a purpose for achieving the mission and an associated value of mission accomplishment. In combat, the mission vectors all combat action, aligning it with the missions and purposes of the war effort. Upon the completion of combat, the outcome is assessed in the light of the post-combat values and costs as seen at (and within) that level and at all higher levels, and the assessments influence further action at all war echelons.

Chapter 5

COMPONENTS OF MILITARY COMBAT

A first step toward describing a theory of military combat is determining the basic components that constitute combat. By *components* we mean the set of all things, in the most fundamental sense, that can be said to make up the phenomenon of combat: the constituents that exist in all combat actions. The task is somewhat like that described by Herman Melville in his chapter on cetology in Moby Dick: "The classification of the constituents of a chaos, nothing less is here essayed."

At this point we will be describing only the components, and the relationships among them, but not how the components perform their functions. Those matters will be covered in later chapters.

5.1 APPROACH

Two approaches have been taken. One uses a top-down method based on the conventional functions of combat. The other, which we consider the more fundamental of the two, can be designated a decomposition-recomposition or bottom-up approach.

5.1.1 Top-Down Functional Approach

The top-down approach examines components from the point of view of any political entity setting out to provide the means to wage combat. This approach is useful to provide a conventional view of components and as a check against the bottom-up approach to ensure the latter does not somehow misrepresent combat as actually practiced. The micro-derived components from the bottom-up approach must mesh with the macro-derived components from the top-down functional approach. The two methods must yield compatible structures even though they entail quite different conceptual approaches.

5.1.2 Bottom-Up Decomposition-Recomposition Approach

The bottom-up decomposition-recomposition approach is the more fundamental because it relates more directly to the structure and dynamics of combat. In this method, a large number of factors (or more accurately topics) that relate to

combat were compiled from an extensive number of documentary sources and individuals. The topics, which cover every gamut of combat, were categorized and grouped, then analyzed. From this we have distilled constituents that appear at every level of combat.

The top-down approach is discussed first.

5.2 COMPONENTS AS DERIVED FROM THE TOP-DOWN FUNCTIONAL APPROACH

Throughout history there has been strong consistency in the components that civilizations have used to wage combat. To examine these from the top-down functional approach, we start with the political entities that, at the highest level, take actions to prepare for combat. Consistent in these actions are the following: defining the threat; developing strategy, doctrine, and tactics; orienting toward goals and control; engendering the will to fight; and organizing and arming forces.

5.2.1 Defining the Threat

Political entities start with an idea in mind as to what kind of an opponent combat may have to be waged against, and where and when it may have to take place. From this they distill a definition of threat. The definition may be specific as to who and where, but more often it is framed in broad, generic terms. An alternative approach is based on the capability to operate in a variety of circumstances against many opponents, in effect against a generalized enemy. Threat definition will also indicate the general intentions ascribed to the potential opponents, such as an emphasis on aggressive or defensive action. Strategic intelligence provides a principal input to defining the threat.

5.2.2 Developing Strategy, Doctrine, and Tactics

Governments and their military establishments develop military strategies aimed at fulfilling the military role within political strategy and goals. Doctrine and tactics in conformance with military strategy are developed to guide commanders and their forces in the conduct of combat. At a lower level, techniques are developed as combat aids for individuals, crews, teams, and small units. These guidelines and techniques are codified into doctrinal, tactical, and technical documents. In modern forces these documents comprise copious volumes of words.

5.2.3 Orienting toward Goals and Control

In furtherance of Axiom 3 (achieving goals), another constituent of combat is its directed orientation toward the goals and objectives of the highest political levels—usually national or alliance levels. Achievement of these goals and objectives has particular value to the political entities. As discussed in Chapter 4, the combat objectives align with war objectives, and the values ascribed to combat outcomes align with the values of achieving the broader goals and objectives. The hierarchical system of organization and command, using directives, mission assignments, and orders, conveys the wants of the government and upper military echelons. National objectives are imposed on forces in combat through the tradition of disciplined observance of orders throughout the chain of command. While the strength of this tradition varies widely from one force to another, its effect is always present.

5.2.4 Engendering the Will to Fight

A paramount constituent of combat is the will to fight and achieve objectives. The will of combat forces to do so flows from the will of the highest governmental authorities and the will of the populace called on to support combat. While this normally falls under the term *national will*, combat forces can also be those of an entity that is not a nation in the accepted sense. The risks of warfare magnify the criticality of will as a component of combat. Governments make concerted efforts to reinforce the notion of willingness to risk life and property for the good of the whole and to overcome the natural reluctance of individuals to place themselves in harm's way. The will to fight will rarely be symmetrical for two opponents and will vary widely for combat forces in different circumstances.

5.2.5 Organizing and Arming Forces for Combat

As stated in Axiom 3, combat potential is embodied in military forces. To create military forces with the potential to wage combat, governments draw on available manpower, material, technological, and geopolitical resources with a view of what the forces may be called upon to do in combat. The consistent patterns in organizing and arming for combat are these:

Structuring forces into units. Forces are organized into units designed to perform particular combat functions. Manning, arming, and supplying are intended to match the functions planned for the unit. The variety of functions, and hence the variety of units, has proliferated as new technology has forced increased specialization of combat units.

Organizing units into a hierarchical-lateral structure. Small units are combined in a hierarchical-lateral structure to form larger units, which in turn are combined into even larger units, this pattern repeating as necessary to reach the size needed. At each echelon, the structure as a whole is designed to be an integrated system with unitary control of the force downward from that echelon.

Establishing control through a command chain. Control of forces is accomplished through unit commanders and the missions assigned to them. The command structure is hierarchical in conformity with unit structure, and the chain of command is meant to exert unified control over the entire force from the highest level to the lowest.

Incorporating deadly and nonlethal armament. Following from Axiom 1, the weapons and equipment used to arm combat forces entail deadly means for offense and defense. Whether weaponry and doctrine emphasize offense or defense, they consistently incorporate the capability to inflict harm. There has been recent interest in adding nonlethal weapons, but even these may harm and they remain backed by lethal weapons. No national-level military force has yet been structured with only nonlethal weaponry.

Dividing resources among fighting, support, and acquiring information. Only a fraction of a military force engages in direct fighting with opposing forces. The remainder is involved in information acquisition and other forms of support to the fighting elements. Some of this comes from military forces outside the combat arena, but at all times a substantial effort within the combat area is devoted to support and information acquisition. As combat has grown more complex, the support and information functions have become increasingly important and have received a greater proportion of resources. In modern forces, only a small part of the total structure is designed for fighting. Despite this quantitative shift in resource allocation, fighting remains the critical function of combat.

Emphasizing joint operations. Differences in the physical environments in which forces operate exert a major impact on force organization, arming, and employment. Forces intended to operate at sea have always been structured differently from those intended to operate on land. The result has been the establishment of separate naval and land forces (and separate marine forces at the land-sea interface), and more recently, separate air and space forces. While this force organization may appear to segregate combat by sea, land, air, and space environments, force organization for the conduct of combat operations more commonly

follows a joint system approach based on the combination of functional needs in each case.

5.2.6 Summary of Top-Down Approach

To summarize, from the top-down functional approach we can see the following components that consistently appear in combat:

- **A defined threat,** providing a generalized or a more specific basis for designing forces for combat.
- **Strategy, doctrine, tactics, and techniques,** codified as guides to the waging of combat in light of the threat.
- **The will to fight,** stemming from the will of governmental authorities, the willingness of the populace to support fighting, and the level of professionalism of the armed forces.
- **Control of combat** oriented toward higher level objectives.
- **The organizing and arming of forces** for combat in hierarchical patterns that are consistent historically and across all forms of government. Included in the patterns are units designed for fighting, support, acquiring information and exercising control.

In the top-down approach, we have identified factors, such as defining a threat and arming forces for combat, that fall outside our definition of combat as active fighting embedded within campaigns and wars. These national level components are part of the external context of combat, which influences what goes on within combat. This will be discussed more fully in Chapter 6.

5.3 COMPONENTS AS DERIVED FROM THE BOTTOM-UP APPROACH

The decomposition-recomposition (bottom-up) approach derives the components of combat in an entirely different manner from the top-down approach and leads to a different view of basic components. The methodology used is similar to that called reductionism, but we do not attempt to push the method as far as is often done in works of science.

The compilation of combat topics in the bottom-up approach covers a wide range of subjects, some broad in scope, some concerned with small details. The list is a mixed bag of terms relating to combat. The small sampling presented in Table 1 illustrates the variety and partial redundancy of the topics as they

appear in unsorted, unorganized form. Compiling the list, categorizing and grouping the topics, and analyzing them is the decomposition part of the approach.

5.3.1 The Basic Components

Analysis of the categorized topics showed they could be organized into three fundamental, independent constituents which have a consistent relation to each other:

- Elements of combat
- Attributes of elements
- Actions of elements

These are the basic components of combat as determined from the recomposition part of the bottom-up approach.

Table 1. Sample List of Unsorted Topics Relating to Combat

Leadership	Training	Surveillance
Chain of command	Estimate of the situation	Ballistic missile
Commanders	Combat intelligence	Meeting engagement
Objectives	Fear of death	Field of fire
Missions	Combat fatigue	Squad
Vehicles	Mobility	Weather
Combat vessels	Courage	Trafficability
Classes of supply	Unit integrity	Collateral damage
Civil affairs	Aircraft shelters	Determination
Landing craft	Attack	Unity of command
Rifles	Defense	Cover
Field fortification	Combat uniform	Corps
Accuracy of fire	Fire for effect	Interoperability
Bombing accuracy	Harassing fire	Bomb loading time
Maneuver	Culminating point	Enemy intentions
Firepower	Suppression	Fuel depot
Dispersal	Resupply	Recuperability
Discipline	Combat friction	Replenishment at sea
Sea sickness	Platoon	Sea state
Reconnaissance	Chance	Cislunar space
Fog of battle	Uncertainty	Initiative
Doctrine	Morale	Synchronization
Tactics	Ammunition	Air superiority

The three components of combat are defined later in the chapter. In addition, we have determined two distinct categories into which each of the element and action components can be divided:

- Physical elements and actions
- Cognitive elements and actions

Each of the three components is distinct from the others; each is an independent part of a triple-leg foundation on which all combat rests. We can envision elements, attributes of the elements, and actions down to the most minute level of combat, and we can combine the minute-level elements and actions, together with associated attributes, into agglomerations of elements and actions up to the highest levels of combat. Or, we can decompose the full scope of combat into smaller and smaller categories of elements (with their attributes) and actions, down to the smallest level. We designate this characteristic as the property of aggregation-disaggregation.

5.3.2 Cognitive and Physical Categories

The basic element and action components are either *cognitive* or *physical*. Physical elements are those that have weight and physical dimensions. The only elements that are cognitive are humans and human thoughts, and the only actions that are cognitive are those by humans. Cognitive actions work as influences on cognitive elements. Individuals in combat are simultaneously both cognitive and physical elements. They are cognitive in that they can think, convey thoughts, and can be harmed mentally; and they are physical in that they have weight and size, need to be fed and transported, and can be harmed physically. Computers using artificial intelligence may approach cognition, but are not independently cognitive. The term *physical* includes elements and actions that involve electromagnetic radiation, which, though it cannot be physically weighed and seen, can produce observable physical effects.

5.3.3 The Triad Relationship of the Components

The basic components have a clear-cut relationship to one another. An *agent element* takes an action that impacts an *object element*, itself, or both. (If it impacts itself, then the acting element is both agent and object.) In any case, the result alters the attributes of the object element. We call this triad relationship a *combat activity*. Normally, more than one object element is impacted by a combat action, and therefore the result of the action involves changed attributes of more than one object element. Moreover, there often are virtually simultaneous actions by other agent elements that also impact the object elements. For example, an enemy object element may duck to avoid the firing action of his opponent, thereby altering his own attribute to a more protected posture. He is acting as an agent element taking an action (ducking) that affects himself. From this we can derive the more generalized definition of *combat activity* as one or more elements each taking an action that impacts one or more other elements, or themselves, or

both, thereby producing a result that changes the attributes of the impacted elements.

The object elements are not limited to elements that have been discretely selected by the agent element. Unaimed fire, for example, can act on any elements in the area where fire is delivered. In the case of discretely acquired targets, the object elements can be in addition to, or other than, the ones targeted. In friendly fire accidents, the object elements are unintended elements of the friendly force. Where fire is intentionally brought to bear on a friendly unit that is about to be overrun by the enemy, the object elements are the enemy and any friendly force elements that unfortunately are also hit. Object elements can be any elements of the friendly force, the enemy force, or the combat environment, and they can be intentional objects or unintentional ones.

5.3.4 Two-Sided Adversarial Nature of Combat

It follows from the axioms that combat involves two forces in opposition. The degree of opposition may be total, in the sense that the attainment of an objective by one side equates to the denial of an opposite objective by the other side; or it may be partial, in that the objectives of the two sides are not complete opposites. In either case, the two sides are in some degree of deadly contention. In war, it is possible to have more than two parties in opposition, but combat involving more than two opponents is such an aberrant case that we have not included it. It is questionable that a situation has ever arisen where three (or more) opponents have simultaneously waged combat against each other.

5.3.5 Environment: The Third Party to Combat

While combat involves two opposing parties engaging in deadly interaction, we must also identify a third party: the combat environment. This is the shared three-dimensional geophysical space and features in which the two adversarial parties wage combat. The combat environment acts as a neutral third party that affects both of the opposed parties. It is neutral in the sense that it does not "take sides" in combat, but it is not neutral in the way it can affect each side differently and the way each side may be able to exploit it to advantage.

As with the adversarial parties, the environment comprises elements with attributes, and the elements can cause actions. The nonadversarial character of the combat environment, however, gives a distinct difference to the manner in which its actions affect combat. The combat environment is not fixed during the course of combat; in addition to changes occurring naturally, it can be modified in some degree by the two sides, as for instance, when fire levels the vegetation and churns the ground.

5.3.6 Internal and External Contexts of Combat

The internal context of combat includes the two opponents and the shared combat environment. But within this internal context, combat is continually influenced by an external context which is essentially unbounded in scope, since it stretches to the national entities supporting combat on both sides and extends to a broad geophysical space far beyond the battle arena. The external context establishes the boundary conditions for combat by both sides, not only at the start of action but in more or less degree continuously throughout combat. Within the internal context, each side will be influenced primarily by its own external conditions from the national or alliance level down to the campaign level, but there will also be an influence from trying to account for the opponent's external influences. Chapter 6 discusses the internal and external contexts in greater detail.

5.4 DISCUSSION OF THE COMPONENTS

5.4.1 Element

The component *element* is defined *as a material or intangible thing of any kind, whether animate or inanimate, that exists in combat and can change the state of another element or itself.* This includes such things as individual soldiers, sailors, marines and airmen, combat orders, plans, weapons, equipment, supplies, and the geophysical combat environment. The environment includes topographic features such as the terrain as a whole, a tree growing on the terrain, hills, airfields, roads, and buildings; oceanographic features such as the seas, islands, and reefs; and atmospheric features such as air, rain, snow, clouds, radiation from the sun, and reflected radiation from the moon. Elements may be either cognitive or physical. As noted, the only cognitive elements are individual humans, together with their thoughts and the contents of their minds. (The case of animals trained for use in combat is a limited and usually inconsequential exception.) Elements may exist as single entities (such as an individual, a rifle, a tree, or a truck) and as aggregated entities of related single elements (such as a battalion, a forest, or a convoy of ammunition trucks). However, while a group of humans, such as a platoon or the staff of a headquarters, is an aggregated physical element, it is not an aggregated cognitive element, since it cannot think as if it were a unitary whole. Each person on the platoon or staff is a separate cognitive element that works cooperatively with the others. Thus, while in the rigorous sense there are no aggregated cognitive elements, the cooperative cognitive actions taken by individuals in a well-trained unit will appear much like collective cognition.

Any categorization of individual and aggregate elements is to an extent arbitrary and case-specific. Nevertheless, designations are implicit in long-standing usage. The ammunition stored in a munitions depot is an aggregated element of similar individual elements; the equipment and personnel in a combat unit is an aggregated element composed of many like and unlike elements, all of which are, however, functionally related. A useful categorization of combat elements can be made clearer through examples. Each of the following is an element of combat:

An individual combatant is both a cognitive element and a physical element.

A rifle carried by a combatant is a physical element. The parts of an assembled rifle are not elements, but spare rifle parts supplied separately are elements.

A squad, with all of its equipment, weapons and supplies, is an aggregated physical element. The squad is not a cognitive element because it does not think as a single corporate body, but it is composed of cognitive elements (the members of the squad) who can take cognitive actions acting in concert. If the squad is diminished by loss of personnel and equipment, the reduced squad remains an aggregated element so long as it retains unit integrity.

An aircraft is a single physical element. An aircraft with its crew is an aggregated physical and cognitive element, as is the aircraft with crew plus loaded ordnance. Each crew member is a single cognitive and physical element. As with the squad example above, the crew members can take individual cognitive actions but will normally concert their mental actions.

A battle-control computer is a physical element. A separable software program that can be inserted into the computer is a separate element, and when inserted into the computer, the combined system becomes an aggregated element. Built-in nonseparable software, such as the computer's operating system, is not an element.

A river in the combat area is an element. So are a road, a hill, a bridge, a forest, and a tree.

An area of combat terrain is a highly aggregated element. Individual topographical elements combine into a single aggregated element of terrain in the same manner as persons and equipment aggregate into a combat unit.

A battalion, a division, a corps, and a joint task force are aggregated physical elements.

The document that constitutes a written combat order is a physical element embodying cognitive meaning which may be read and understood as a cognitive action.

Radiation from the sun is a physical element, although a highly diffused one. When the radiation shines on an object, heating it and making it more visible, the radiation is taking an action. Like radiation, the earth's magnetic field is an element.

The mental indoctrination instilled over years in the mind of a commander or any individual combatant is a cognitive element, but it is subsumed in the individual as an inseparable part of his state. An individual and his mental faculties are the same cognitive element. But an individual's thought process (in formulating a course of action, for example) is a cognitive *action*, and when that individual conveys his thoughts to another (say by giving verbal instructions), he is taking a second cognitive action to influence and change the cognitive state of the other person.

5.4.2 Action

The component *action* is defined as *an act performed by a single or aggregated element to change the state of one or more other elements, its own state, or both.* (The term *state* is defined below.) Since actions require a small but finite time for completion, they, unlike elements and attributes, inject time flow into combat. Actions encompass every act that takes place in combat: acts by individual elements and acts by aggregated elements. A soldier (single element) using his rifle (single element) to fire a round (single element) has performed a single action, that of firing. A missile-carrying destroyer and crew (an aggregated element) firing a salvo of rockets (each rocket a single element) using all of its launchers (each a single element) has performed an aggregated action. Conversely, this aggregated action can be broken down into the many single actions involved. Thus actions, like elements, have the property of aggregation-disaggregation.

Actions have no substantive existence; they cannot be shot at, destroyed, moved, or stored. One cannot attack an action. Only elements can be attacked, destroyed, moved, or otherwise subjected to the actions of combat. Likewise, only an element can perform an action. The relationship between elements and actions is the same as that between nouns and verbs. In the grammar of combat, elements (nouns) carry out actions (verbs) against other elements or themselves. Although

elements do not carry out actions against actions, elements have an indirect effect by acting against other elements that perform actions.

All actions are carried out by one element affecting another element or elements (including itself). This applies even to actions caused by environmental elements (such as the actions of raining, heating caused by the sun, and other weather-caused actions). Actions thus always have objects: action is directed *upon* one or more elements. In the grammar analogy, actions are transitive verbs.

Actions are either physical or cognitive. Actions which derive from thinking are cognitive, and these originate only with cognitive elements (humans). Actions by all other elements are physical (humans also perform physical actions). Every action by an animate or inanimate element (except for events attributable to acts of nature) commences with a human cognitive thought to set the action in motion, and hence every action in combat must be preceded by a cognitive action. A gun does not fire by itself and a truck does not move by itself; someone decides to have the gun fired and the truck moved. An antipersonnel mine in a minefield does not go off until a soldier makes a decision to move across the minefield. In addition to natural events, a possible exception to this principle can be included for actions attributable solely to failures of equipment, such as a computer shut-down because of battery rundown.

The following illustrate what is included within the component action:

- Deciding a course of action (a cognitive action)
- Stating a order verbally or composing it in writing (cognitive actions)
- Exhorting a unit to perform well (a cognitive action)
- Transmitting a written order; receiving a written order (both are physical actions)
- Firing one round from a weapon; firing a salvo of rounds
- Steering a boat; flying a reconnaissance mission
- Transporting a combat unit from one location to another
- Repairing a tank
- Storing intelligence information in a computer
- Capturing a terrain feature
- Destroying part or all of a bridge

- Suppressing a force
- Surrendering a force
- Snowing within the combat area
- Changing of the weather, as from clear to cloudy
- Changing of the sea state, as from calm to heavy seas

Most of these are aggregated actions. Although only the first three of the list are cognitive actions, all except the last three require cognitive actions before they can be initiated and most require additional cognitive actions to complete execution of the action. For example, the action of destroying a bridge is physical but requires the cognitive action of making a decision to have the bridge destroyed and a great many other cognitive decision actions to initiate the physical actions of transmitting orders, positioning forces, and firing weapons. The last three on the list are actions that man does not control and for which, therefore, there is no preceding cognitive input.

5.4.3 Attribute

The component *attribute* is defined as *a qualitative or quantitative modifier of a combat element*. Attributes provide the differentials that distinguish one element from another. Attributes are not in themselves either cognitive or physical, but they can modify either category of elements. When they modify elements, attributes correspond to adjectives, and when they modify actions, they correspond to adverbs. Although attributes cannot themselves be aggregated, they modify individual elements which become aggregated, and the effect is as if the aggregated element takes on the combined attributes of the many elements. To illustrate, a tank platoon (an aggregated element) comprising individual tanks each with a certain attribute of cross-country mobility becomes a platoon with essentially that same attribute of cross-country mobility. Similarly, where every member of a bomber or ship crew has the attribute of high morale, the aggregated crew displays that same attribute, but if some have high morale and others do not, the aggregated crew will display a mixed attribute.

Attributes are of three kinds:

- **Spatial conditions**: these are the time-space characteristics of elements, which include location in three-dimensional space at any moment of time, orientation in space (pointing this way or that, standing upright or lying down, and so on), and instantaneous motion (moving in a

circle or linearly, rotating, motionless). Spatial conditions apply only to physical elements.

- **Physical properties**: these are descriptors of elements, both human and other, that can be stated and measured in physical terms, such as dimensions, weight, shape, configuration, composition, muzzle velocity, range, explosive force, and load-carrying capacity. Physical properties pertain only to physical elements. Properties of elements of the environment can include steepness of hills, density of foliage, heights of buildings, strength of fortifications, density of clouds, temperature, and so on.

- **Qualities**: these are nonphysical, subjective descriptors of both physical and cognitive elements, such as motivation, durability, reliability, slowness, vulnerability, intelligence, tractability, brevity (e.g., of orders), and manpower intensiveness. Qualities differ from physical properties in that they cannot be as specifically quantified and described, and they apply to cognitive elements as well as physical ones. They also include a sense of "goodness" or "badness," depending on the situation in which the element is operating. For example, weapons of short range in a force are generally not as good as the longer range weapons of another force; but if the short-range weapons are more accurate, they may on balance be better. Clear comprehensibility of an order is always a quality of goodness. Lack of intelligence in a commander is a bad quality. Short message transmission time is good. The will of an individual to fight can be changed from strong (good) to weak (bad). These examples show that qualities are less concrete than physical properties and spatial conditions. For some qualities, what is good in one situation may be less so or bad in another circumstance.

5.4.4 State

At any instant of time the combination of an element and its attributes is designated the *state* of that element. *State* is defined as *the condition of existence at a point in time of a single or aggregated element, as determined by its cognitive and physical attributes, including its spatial condition.* Every element from individual persons and individual items of materiel up to complete multinational forces has a state at any moment of time. The states of elements, both single and aggregated, will be frequently changing during combat. As perceived by combatants, the changes appear to be continuous. The component "action" is not a part of state, but the actions of elements result in changes of state of all affected elements.

Like the three basic components, state has the property of aggregation-disaggregation. Thus, state can be aggregated by combining the states of the smallest elements into the states of larger elements, and the largest element can be decomposed into states of the smallest elements. The combination of individual element states into the state of an aggregated element is not, however, an arithmetic summation of the individual states, for, as discussed in Chapter 6, there are nonlinear effects at play.

The states of elements are changed by the triad element-action-element activities that are constantly taking place in combat. These activities have results, and the results are the changed states of the elements acted upon.

5.5 SUMMARY: BASIC COMPONENTS AND THEIR RELATIONSHIPS

This section sets forth the basic building blocks that universally constitute combat. All of combat, from the smallest granular level to the full scope of all forces engaged, can be composed from three basic components. Each of the three components is distinct from the others, but they are linked in relationships that hold consistently throughout combat. Figure 4 illustrates the relationships.

The components are:

- *Elements*, which are all the material and intangible things existing in combat. Elements may be cognitive (having mental capability) or physical.
- *Actions*, which are acts carried out by elements upon other elements or upon themselves, thereby changing the states of the elements acted on. Actions may be cognitive (stemming directly from a mental process) or physical.
- *Attributes*, which are descriptive modifiers of elements. Attributes are of three kinds: spatial conditions, physical properties, and qualities. The attributes of cognitive elements are limited to qualities.

There are three separate parties to every combat:

- *Each of the two opposing forces*, and
- *The geophysical combat environment*, which acts as a non-adversarial third party.

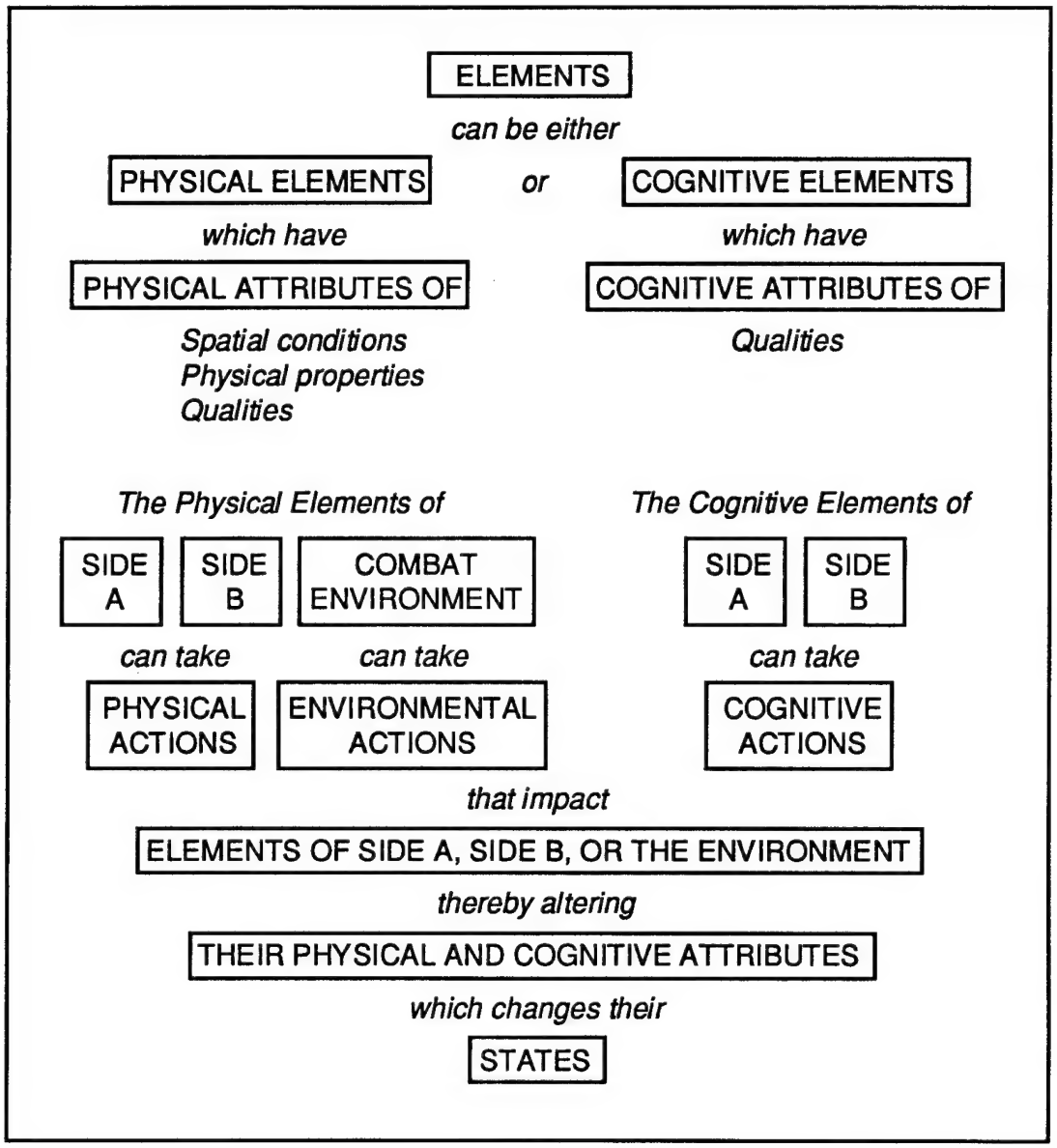


Figure 4. Relationships of Components of Combat

All of the physical and cognitive elements (as modified by their attributes) of the two opposing forces and the environment, together with all of the actions taken by elements over time to impact other elements and the results of those actions, constitute the totality of combat. This is the *internal context* of combat. The internal context is embedded within and continually influenced from the outset of combat until its conclusion by the *external context,* which extends to the highest political levels and broadest geographical areas on both sides of the conflict.

There are consistent patterns in organizing and arming for combat. Combat forces are organized by aggregating elements into functional units that are

linked laterally and hierarchically into functionally oriented echelons that are controlled from the top down through a command chain responsive to the highest level. Combat forces are oriented and vectored toward the goals and strategy of the governing entity and are infused with the will of the populace and the political authorities to pursue their assigned missions at high personal risk.

The decomposition-recomposition approach provides the fundamental building blocks necessary to understand combat structure and dynamics, while the top-down functional approach provides patterns of force structuring and connects combat to the larger war picture. The two approaches are complementary and not antithetical.

The manner in which elements, actions, and attributes are structurally related, and the impact of the external context upon the internal context—sometimes constraining and sometimes impelling combat—will be taken up in the next chapter.

Chapter 6
STRUCTURE OF COMBAT

This chapter brings together the components of combat and the internal and external contexts into a structure descriptive of the combat phenomenon. The structure unites external and internal contexts, functional relationships among the components, mission, and the outcome of combat with space and time dimensions.

6.1 BOUNDARY CONDITIONS AND THE EXTERNAL CONTEXT

Combat does not occur as a closed or isolated system. Its conduct is affected by the initial conditions shaped by the external context at the commencement of combat. As combat proceeds the external context continues to exert an effect. The external context provides the initial impetus and constrains combat to conform with the campaign and war levels and with political factors. Thus, before and during combat it forms the boundary conditions that influence the course of events.

The external bounding influences have become increasingly significant as combat has become more dependent on forms of multiservice support and weapons systems remote from the combat arena. Intercontinental transport of forces, satellite systems providing intelligence and positioning information, and long-range missile and aircraft systems are a few of the remote capabilities that now interface with local combat. Advances in communications enable near-real-time injection of controls from command levels far from the combat area and near-immediate feedback of combat progress to those levels, complicating command during combat.

Table 2 lists some of the variables that contribute to the boundary conditions; many additional factors also come into play. Boundary conditions are formed by the purpose-value-mission framework of the war and the campaign, together with capabilities and constraints from the external geophysical environment and the general situation vis-à-vis the enemy. The more immediate initial conditions are those existing just before the preparatory phase of combat—the forces about to be involved (with their combat potential at the time), the mission or task assignment, the enemy force expected to be in opposition, conditions created by the environment within the combat arena, and the information available about all of these factors.

Table 2. Variables Illustrative of the External Context

War Context
National (and alliance) war goals
National (and alliance) will and support of the war effort
War leadership
War strategy and objectives
War doctrine
Available manpower resources—quantity, quality, morale, readiness, leadership, motivation
Available material resources—quantity and quality of weapons, communications, support
Future availability of manpower and material resources
Intelligence systems and intelligence available
Immediate war situation prior to the combat
Intentions for war actions subsequent to the combat
Campaign Context
Campaign leadership
Campaign mission and objectives
Campaign doctrine
Rules of combat engagement; other war constraints
Forces and support available at the campaign level; availability for diversion to the combat
Combat potential of forces planned for the combat
Reinforcement and replacement forces and support to be expected
Concept of how the combat fits with campaign plans
Estimate of the costs of conducting the combat
Intentions for campaign actions subsequent to the combat
Geophysical Environment External to the Combat Area
Geographic, oceanographic, aerographic, and outer space environments
Climatological conditions
Recent and forecast weather conditions affecting the external environment
Man-made infrastructure, such as roads, seaports, airports, urban centers
The Opponent's External Context
At the war level: intelligence information about the same war categories listed above
At the campaign level: intelligence information about the opponent's campaigns
At the geophysical environment level: intelligence about the opponent's environment

6.2 Primitives of Combat Structure

Development of combat structure starts with single elements acting on single elements, or small units of only a few elements acting on other small units, all subject to influences of the boundary conditions. The smallest animate element is a single soldier. Examples of the smallest inanimate elements are a vehicle and a howitzer. Aggregation of single entities into small units and of small units into

larger units is governed by commonalities of the attributes and functions of elements. A squad and an aircraft crew are examples of small unit aggregations. Working with individual elements and small unit aggregations, we will describe a micro-structure of combat—structure as it occurs at the lowest level of combat.

6.2.1 Combat Micro-Structure

Figure 5 illustrates the basic ingredients of combat structure at the micro level. The external context acts on and influences the form and flow of combat activity over time, represented in stylized fashion by the rest of the figure. Mission provides specific internal direction to combat activity and vectors it through command and control.

The figure illustrates a microcosm of combat in which an element engages in an action that affects itself, affects one or more other friendly force elements, one or more enemy elements, or environmental elements. The effects of the actions are labeled RESULT. As stated in Chapter 5 the attributes of an element determine its state. The result of an action is a change in the attributes of the object elements (those being acted on), and thus their states. To the extent the agent element (the one performing the action) changes its own attributes (therefore its state), it becomes both object and agent element. In some cases, an action results in destruction of an element, and the change of state then becomes that of physical elimination.

The actions and the changes of state occur over a small but finite period of time (shown in Figure 5 as Δt). Changes of state are indicated in the figure by dotted arrows directed from the "result" symbol to the "element" symbol.

As indicated in the figure, element-action-element sets with associated results constitute the combat activities defined in Chapter 5. These fall into a few basic categories:

- **Single-action activity** - Blue force tank (Element 1) fires on Red force tank (Element 2). The results are Red force tank damaged (change of state of Element 2) and Blue force tank ammunition expended (change of state of Element 1).

- **Multiple-action activity** - Red force tank (Element 2) moves to take cover while simultaneously firing on Blue force tank (Element 1). The results are Red force tank at a new spatial position and ammunition expended (two-fold change of state of Element 2), and Blue force tank crippled (change of state of Element 1).

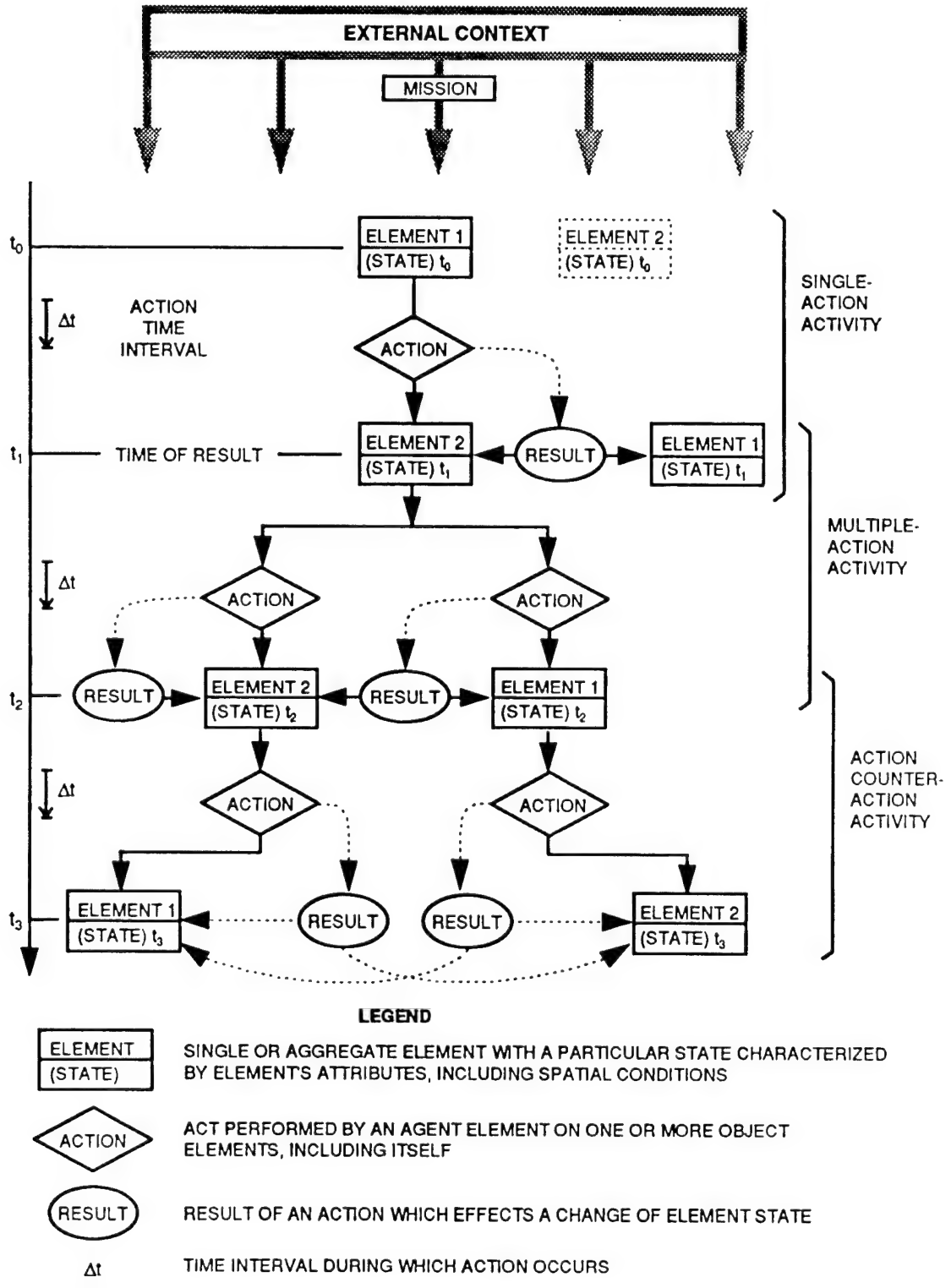


Figure 5. Microstructure of Combat Activity

- **Action-counter-action activity** - Blue force tank (Element 1) fires on Red force tank (Element 2) and Red force tank returns fire. The results are Blue force tank ammunition expended but tank destroyed (two-fold change of state) and Red force tank ammunition expended and tank damaged (two-fold change of state).

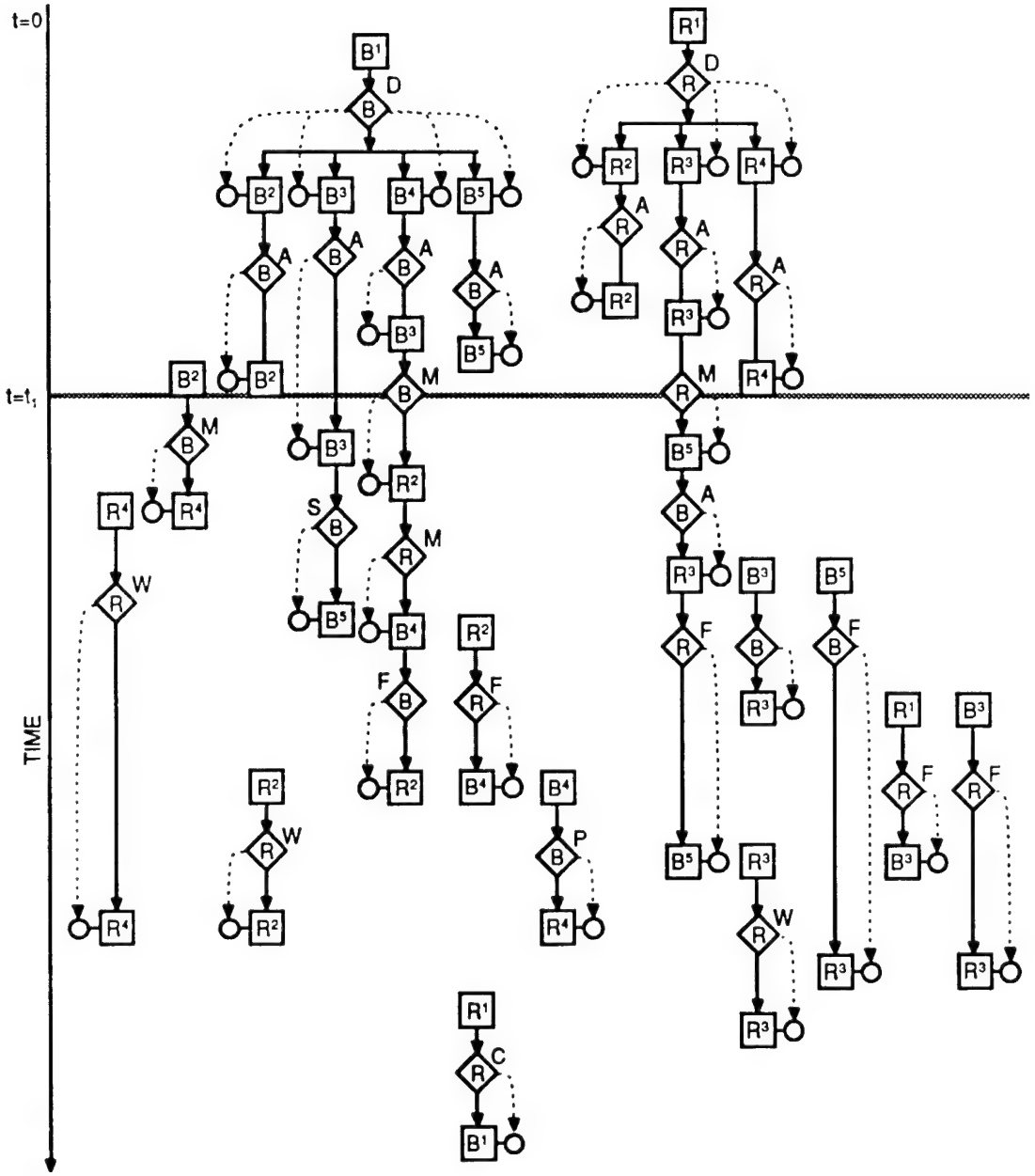
- **Multiple object-element activity** - Blue force tank (Element 1) fires on two Red force armored personnel carriers (Elements 2 and 3). The results are one Red force personnel carrier destroyed (change of state of Element 2) and one personnel carrier damaged (change of state of Element 3), and Blue force tank ammunition expended (change of state of Element 1).

At this fine-grained level, combat structure is the assemblage of many such element-action-element activities in various combinations. In Figure 5, the explicit independent variable is time, progressing from top to bottom. The actions and the changes of state of each activity take place over a small but finite time interval. Spatial changes of the elements (in three dimensions) are implicitly tied to events in the figure as time progresses.

6.2.2 A Micro-Structure Scenario

In principle, any combat can be decomposed into elemental activity chains, creating figures of great complexity. Using a simple hypothetical firefight scenario, such a construct has been made in Figure 6. Force element sizes have not been specified in the scenario, nor have the constraints of geophysical environment and external contexts. However, elements and their actions in the scenario can be thought of as aggregations of single units within limits of element homogeneity and commonality of individual actions. In aggregating to any degree there is a loss of precision and detail in defining battle activity.

We can take a time cut across Figure 6 (at, for example, $t = t_1$) and then examine the resulting fixed-time cross section of the combat. The time cut reveals every force element on both sides, the state of each element at that moment, and the action, if any, the element is taking. If Figure 6 had included the combat environment and the external context, the time cut would also reveal the states of their respective elements at that instant of time. Additional time cuts across the figure would produce similar patterns of information. The question remains as to whether a generalized fixed-time cross section of combat could be derived from such information.



LEGEND

B — Blue Force Elements; B^1 = Blue Force Command Element; B^2 to B^5 = Other Blue Force Elements

R — Red Force Elements; R^1 = Red Force Command Element; R^2 to R^4 = Other Red Force Elements

B — Action by Blue Force Element — D=Direct A=Advance M=Maneuver S=Reinforce

R — Action by Red Force Element — P=Pursue W=Withdraw F=Flee C=Capitulate

○ Result

Figure 6. Time History of a Firefight

6.3 A SLICE OF COMBAT IN FIXED-TIME

Two procedures are needed to produce a generalized fixed-time cross section of combat. One calls for examination of combat structure from the bottom up and the other from the top down. The two procedures parallel the bottom-up and top-down approaches to determining the components of combat.

6.3.1 Bottom Up: from Micro to Macro

This procedure starts with the smallest combat elements and their activities. It then groups elements and activities through a process of aggregation into larger entities more in keeping with a commander's view of traditional organization and operations. Drawing on the firefight of Figure 6 as an example, we undertake at some fixed time (such as t_1 in the figure), an aggregation into groupings for the two opposing sides:

Elements of like kind
Actions of like kind
Activity results of like kind
Influences from the external context of like kind.

In addition, elements and actions of the geophysical environment affecting each adversary are similarly aggregated into like groups.

To guide arrangement of the groupings into a meaningful pattern of forces, actions, results, environment, and context, we must draw on knowledge of combat and the traditional organization of resources used in combat. The latter is provided by a top-down view.

6.3.2 Top-Down: from Macro to Micro

Governments have, since early times, organized and armed combat forces in consistent task-oriented patterns of four general functional areas: fighting, support, information acquisition, and command-control. Of these, it is the fighting function that primarily impacts the enemy. In a modern force, a major part is applied to support, information acquisition, and command-control functions, and a minor part to fighting.

By decomposing, we can identify in the top-down approach layers of hierarchical structure from the level of national command authority down to the individual combatant.

This process of decomposing, in conjunction with the process of aggregating from the bottom up, leads to a useful construct of combat structure. The top-down view connects the detailed individual view of structure to the larger geopolitical picture and the war. The bottom-up view provides the underpinning necessary to understand combat structure and dynamics. The two views are complementary and non-contradictory.

6.3.3 Generalized Fixed-Time Cross Section of Combat

Using concepts outlined above, a diagram can be constructed that represents a generalized fixed-time cross section of combat structure—a slice in time, so to speak. This is shown in Figure 7 which consolidates categories of forces, activities, and results of the two opposing sides and the shared combat environment. The result is a time-instantaneous diagram of structural relationships that is universal for any form of combat and for any level of combat, in effect, a snapshot of combat. All the forces, activities, and relationships shown are present at every instant of time in combat, but in varying degrees as conditions change with time. The quantitative and qualitative specifics of forces, activities, and results will vary widely from one combat to another. Information acquisition is carried out not only by those force elements specifically charged with this task, but also by support forces and fighting forces. Every individual in combat will engage in information acquisition at one time or another.

Force and functional relationships. The generalized forces and functional relationships shown in Figure 7 are composed of myriads of the elemental forces and activities illustrated in the firefight of Figure 6. All the actions of the two sides and the combat environment interact in the "Combat Interaction" block of Figure 7 to form the interactive combat processes (discussed later). Actions of the fighting forces and the intelligence gathering elements of one side interact with those of the other side in a direct, confrontational manner. Forces carrying out other actions interact primarily with own-force elements and only indirectly with enemy forces.

From the interactive processes, the actual results of combat are formed, indicated in Figure 7 as changes of state in the Blue and Red forces and the combat environment and the degree of mission accomplishment by each side. Information about the results is acquired and perceptions based on the information are fed back to the command element. The figure, taken as a whole, represents the three-sided combat situation at a moment in time.

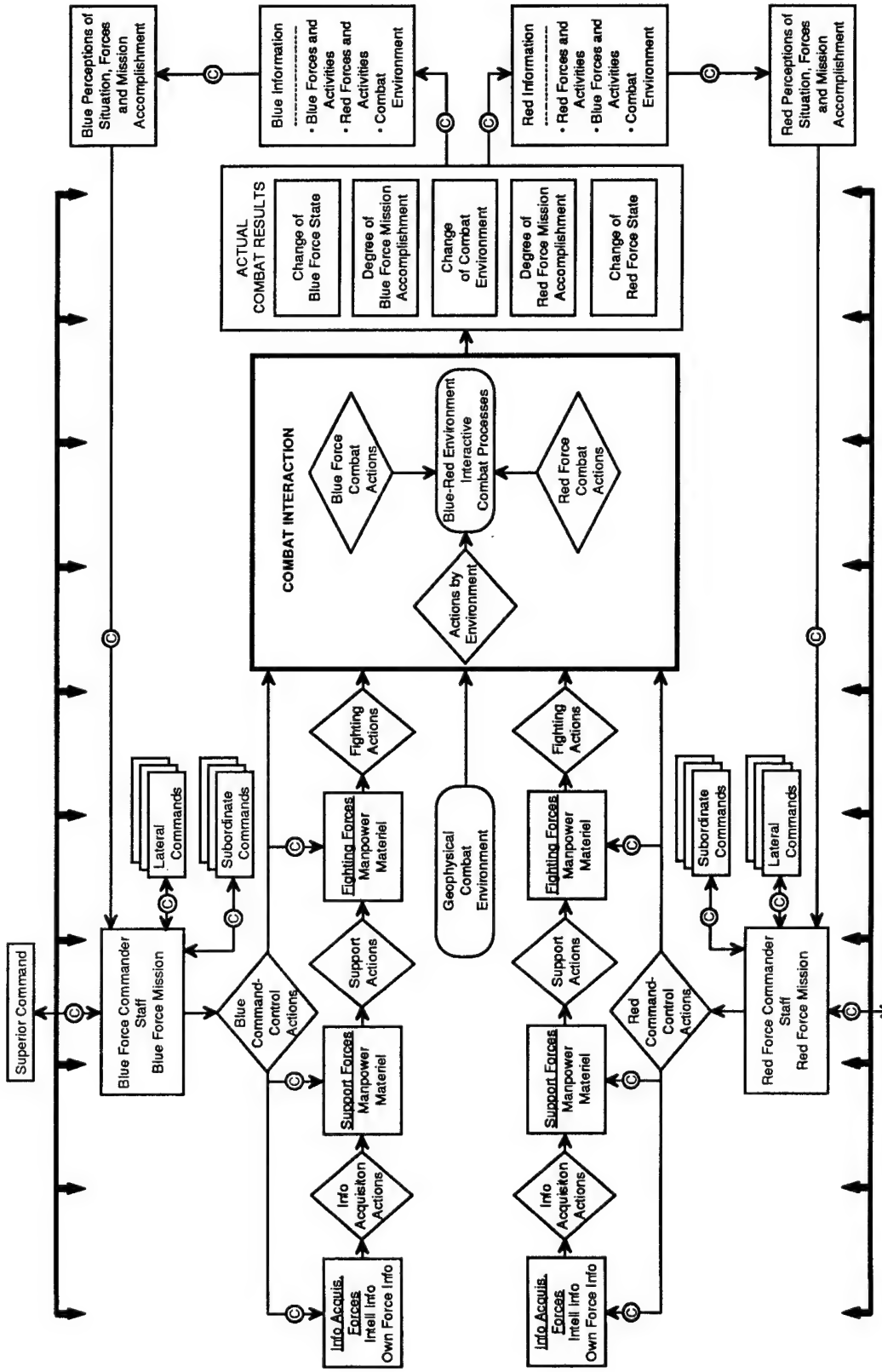


Figure 7. Generalized Fixed-Time Cross Section of Combat

Structural symmetry and hierarchical congruency. There is complete symmetry of structure between the two opposing sides. Obviously this does not translate into symmetry of capabilities of the two sides. In addition, the two sides share the results of combat, the combat situation, and the geophysical combat environment. And obviously, the effects on the two sides of the environment, results, and situation are never symmetrical. The environment, for example, may favor or handicap one side, and one side may be more susceptible than the other to certain environmental impediments. Although both sides share the combat situation, each side has incomplete and only partly correct information of the emerging results and the actual states of both sides. Each side therefore works with perceptions of reality, rather than with absolute reality. This is a universal feature of combat structure.

The relationships of forces and activities shown in Figure 7 are hierarchically congruent through all levels and kinds of combat: they are independent of the combat force echelon (the figure applies equally to squad-size and to larger forces) and independent of the combat domain (land, sea, air, space, or any combination). The Blue and Red commanders and staffs shown are situated within organizational hierarchies that include superior, lateral and subordinate commands, and each has a mission or task that likewise is part of the mission hierarchy. At every echelon, each side has manpower and material resources at its disposal to perform command-control, fighting, support and information gathering functions, which may or may not be adequate for the mission imposed. Each side is bounded and influenced by its own external context.

Perception versus reality. The actual combat results at any instant are measures of the degree of mission accomplishment by each side—in effect, incremental measures of effectiveness for each of the opposing forces. The cumulative results over time of these instantaneous snapshots will be cumulative measures of combat accomplishment and mission achievement for each side. But actual results will differ from results as perceived by the two sides. Perceptions of physical and cognitive results are derived from friendly situation reports and from scouting, reconnaissance, surveillance, and other intelligence activities, all of which are subject to analysis and interpretation and thus all are less than perfect. Perceptions of combat—not the reality—are used by both commanders and all other combatants in planning, decision-making, controlling, and all other cognitive actions.

The command-control, support and information acquisition actions are generally similar for all military forces but differ in the details of implementation. There are, of course, major differences in the fighting actions. Part of combat support and information acquisition may come from external pools of manpower and materiel, but most is embedded within the combat force structure itself.

A simplified cross section of combat. Figure 8 presents a simplified version of Figure 7. Here again, the structural symmetry in elements and functions of the two sides is evident. But, as stated earlier, structural symmetry should not be taken to mean symmetry in carrying out functions in a given combat situation. Asymmetries arise from all sorts of differences ranging from the external context to every aspect of dynamic interaction.

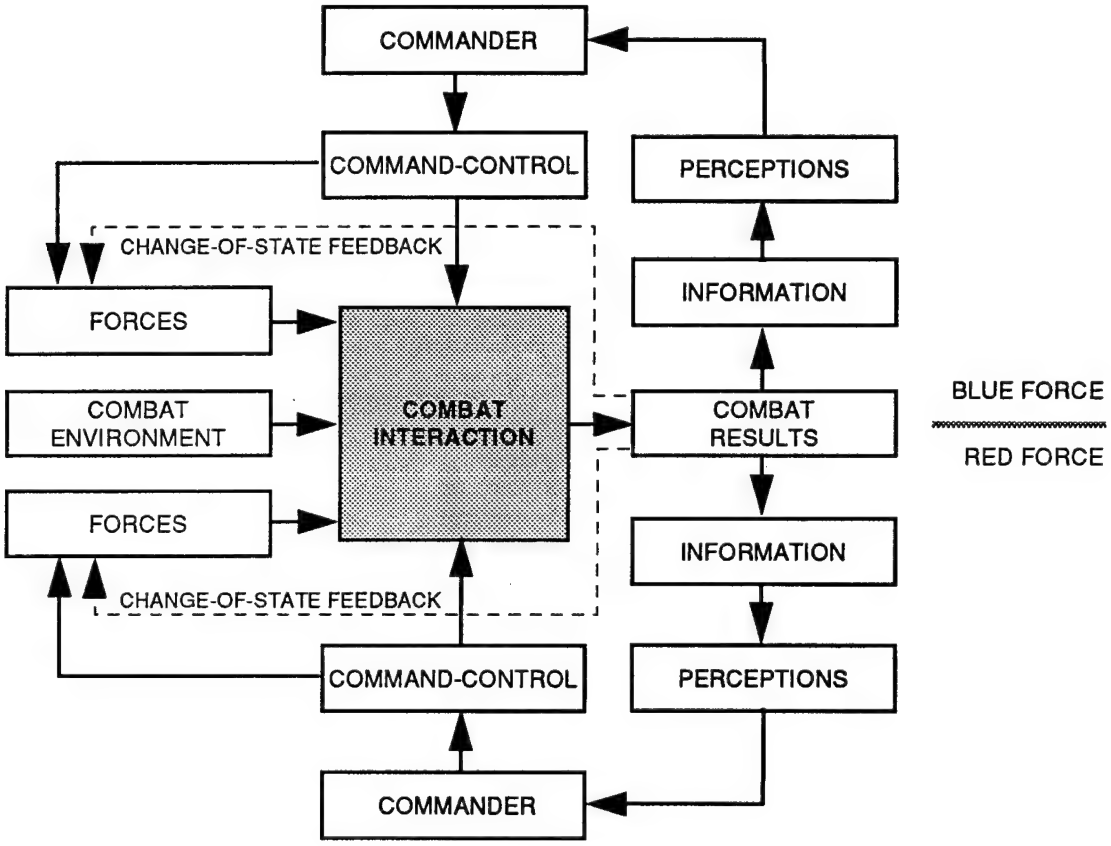


Figure 8. Simplified Fixed-Time Cross Section of Combat

6.4 FUNCTIONS AND PROCESSES

6.4.1 Distinction between Combat Functions and Combat Processes

Earlier, we grouped related elements, actions and activities across a slice of time into aggregations. We now group related combat elements and actions into *primary combat functions*, and related combat activities into *primary combat processes*.

For each grouping—functions and processes—we select the minimum set of categories that will cover all actions and all processes of combat. In both cases, the selection of the minimum set is arbitrary, but in both the set is defined as encompassing, respectively, all functions and all processes that occur in combat. It is possible to argue for more or fewer categories in each set, or to subdivide functions and processes almost indefinitely, winding up with a vast number that differ only slightly. Nevertheless, these two sets, chosen arbitrarily but judiciously, seem well suited for the purpose of describing a theory of combat.

The difference between combat functions and combat processes is that the processes are oriented to results actually achieved against object elements in the three-sided amalgam of combat, whereas functions are oriented to results that agent elements intend to achieve by their actions. Functions are the means—the actions taken by elements—unilaterally employed by each side to obtain desired results. Processes, in contrast, are the activities of all three parties in combat that create actual results—the new states of object elements. Thus, combat functions are the input-oriented actions directed by commanders, while processes are the output-oriented accomplishments of the actions, taking into account what the enemy and the environment may do to attenuate the effect.

Figure 9 illustrates the difference between function and process, using a combat activity in which the actions of both sides and the combat environment play their parts in determining the result. The process is formed by the interaction among the three parties.

6.4.2 Primary Combat Functions

A *primary combat function* is defined as a generic category of like actions taken by elements of either adversary in combat to achieve an intended result. Primary combat functions at the lowest level (individual elements taking individual actions of like kind) are aggregated into primary combat functions being carried out by aggregated elements taking actions of like kind at that moment in combat. Some functions are performed internally to support own-force activities, while others are directed against the enemy, in both instances the functions being directed toward mission fulfillment. The enemy, in turn, performs appropriate functions to further his own mission and to counter his opponent's actions.

Action is the enabling mechanism for combat functions. It is undertaken by an agent element impacting an object element with some particular result intended by the agent that may or may not be realized. The reasons for disparity between intent and outcome include imperfect execution of agent action, environmental interference, counteraction by the object element, unrecognized conditions of object state, and so on. Combat process, relating as it does to what is actually

obtained as results, is not affected by uncertainties and unknowns afflicting forces, and thus is the reality of combat. Nevertheless, the cause of all combat activity is the performance of functions—the actions initiated by commanders and carried out by forces.

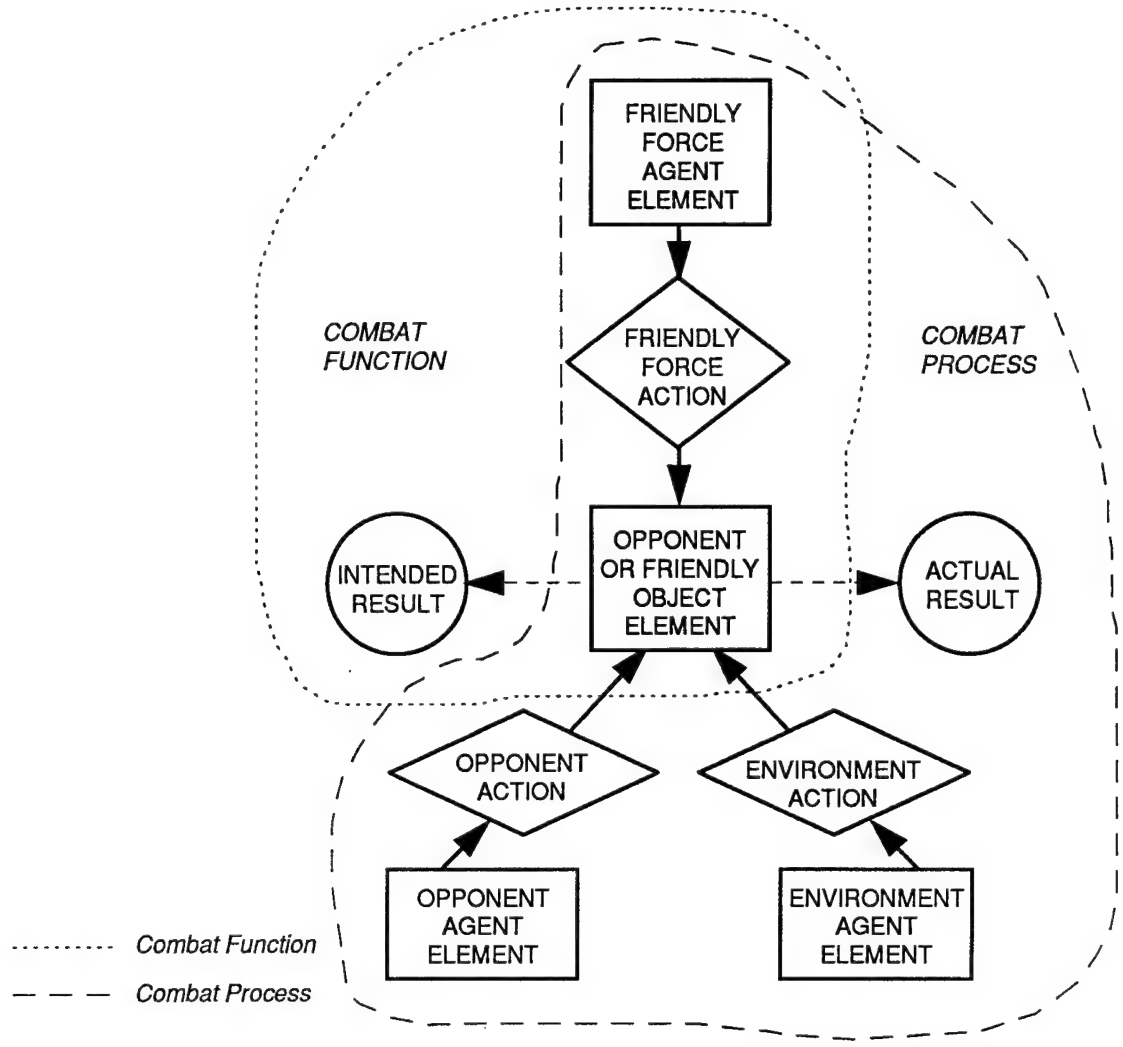


Figure 9. Distinction Between Combat Function and Combat Process

The Primary Combat Functions. Any list of combat functions will vary from source to source, depending on terminology, specificity, the kind of forces they pertain to, and the sort of combat involved, but all lists reflecting modern joint warfare will resemble one another. Two lists of combat functions are shown in Table 3, one based on the Universal Joint Task List (Tactical) and the other adapted from the 1986 edition of the U.S. Army Field Manual 100-5, *Operations*. From the two lists, we have developed a generalized set of four primary combat functions (Table 4) that are broad enough to include every function of combat.

The same primary combat functions are available to both sides, and each side uses them to further its mission and to counter actions by the opponent.

Table 3. Lists of Combat Functions

Combat Functions From Universal Joint Task List	Combat Functions From Army Manual of Operations
Exercise command and control Conduct maneuvers Develop intelligence Employ firepower Provide mobility Provide survivability	Command and control Maneuver Fire Intelligence Tactical air operations Suppression of enemy air defense Engineer support Communications Airspace coordination Deception Electronic warfare Reconstitution Psychological operations Amphibious operations Special forces operations Civil-military operations Sustainment, including arming, fueling, maintaining, repairing, transporting, protecting

Table 4. Primary Combat Functions

Command-control
Fighting
Support
Information acquisition

The command part of the command-control primary function is performed by all in the command chain (including anyone assuming command) and their staffs. This involves the weighing of information, the formulation of decisions, and the dissemination of decisions and directives. The control part of the function is performed by all other persons who carry out command decisions. The function also includes signals that control weapon systems, such as guidance commands to a missile, and those that interface with humans, such as electronic warning to an air crew of an approaching enemy missile. Communicating is part of the command-control function. The fighting function includes all the actions directly carried out against enemy forces: delivery of firepower, maneuvers, deception actions, offensive electronic war actions, and many other offense and defense

actions. The support function encompasses not only longer-term forms of sustainment, but also provides for the immediate needs of fighting forces. It includes sustainment of both manpower and materiel resources, encompassing health and medical support, maintenance and repair of equipment, providing munitions and fuel, transporting, engineering support, and the like. The primary combat function of information acquisition includes the gathering of information about the enemy, about the friendly force, and about the combat environment—in short, the gathering of all information about the combat situation. The processing of both own force and intelligence information to formulate combat decisions falls under the command-control function.

Interdependence of Functions. The symmetry of forces and functions between the two sides is clearly shown in Figure 7. Less apparent is the interdependence of the four primary functions for each side: active fighting, support, information acquisition, and command-control. This is better illustrated in Figure 10, where for the sake of simplicity, the fixed-time cross section of combat is shown in abbreviated form for only one side. The command-control function, working through the chain of command, vectors fighting forces to move toward mission accomplishment to remove enemy opposition. At the same time, the command-control function directs the acquisition of information needed and directs support forces to enable fighting forces to proceed in their tasks. All four functions must be carried out successfully to achieve the mission. Each depends on the other three, as symbolized by the linked rectangles in Figure 10. The command-control function is essential to initiate purposeful actions by the other three, and depends on information being acquired; the fighting function must be sustained by the support function to continue its tasks. What results from the combat functions of one side is affected by the combat functions of the other side, and from this interactive mix come the combat processes and the actual results of combat.

In addition to these four interdependent functions, we must introduce the notion of counter-functions that can be engaged in by the other side. The counter-function to command-control includes all measures taken by one side to disrupt, confuse or destroy the other side's capability to make sound decisions, disseminate information and control forces. The counter to information acquisition is keeping own-force information secure. These are aspects of information warfare. Counter-support takes the form of interdiction and destruction of the enemy's capability to sustain his forces with weapons and other materiel, including sustainment from outside the combat arena. Similarly, there are counters to all of the activities involved in the fighting function.

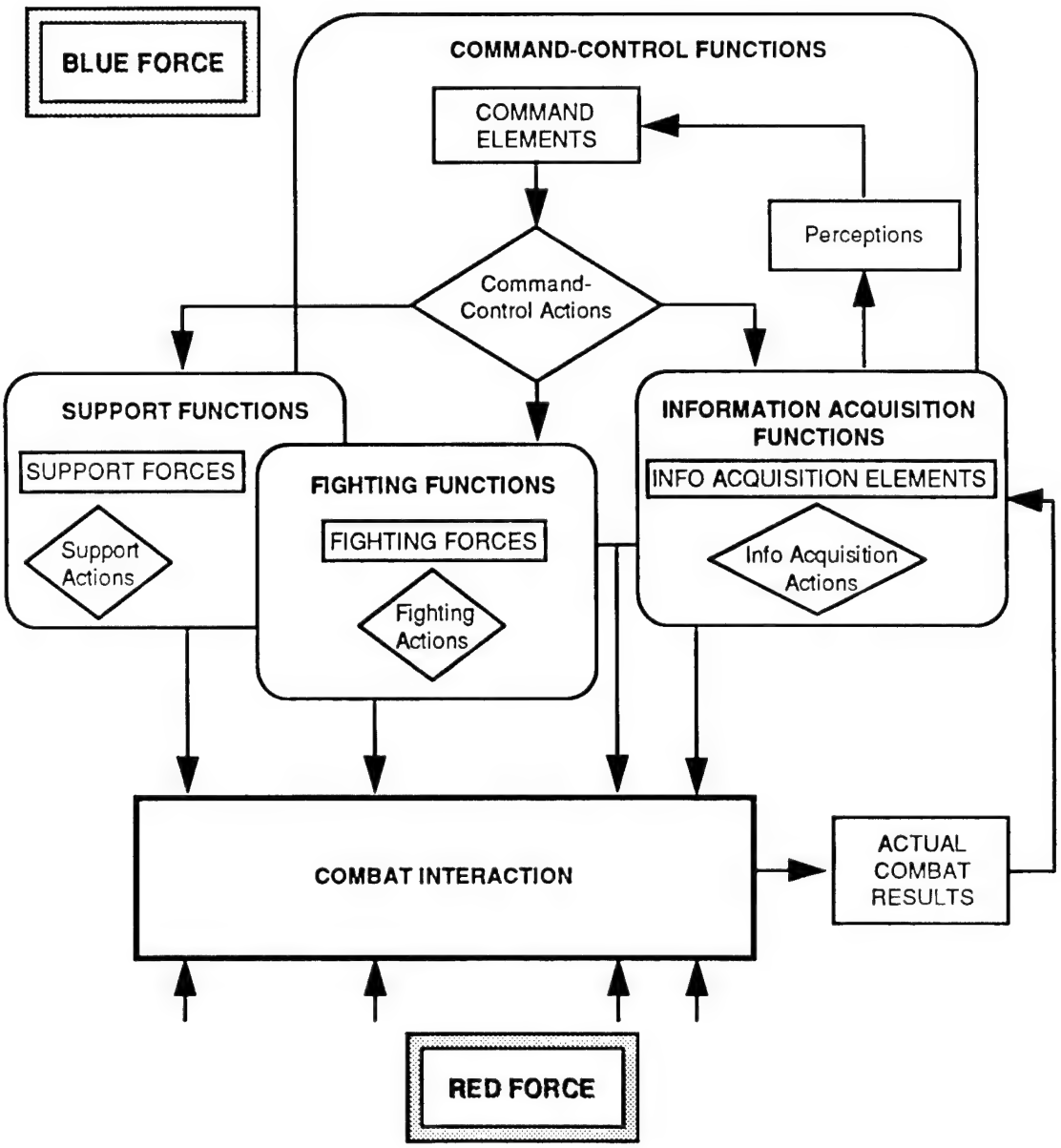


Figure 10. Relationship of Command-Control, Support, Information Acquisition, and Fighting Functions

6.4.3 Primary Combat Processes

A *primary combat process* is defined as combat activity of any kind that produces a common generic result. Since combat processes include every component of combat—elements, attributes, and actions, together with actual results and new states of elements—the primary combat processes, taken together, represent the totality of what happens in combat. Every combat function initiated with some intended result will generate one or more combat processes that will, in the

three-sided interaction of combat, lead to the actual results of combat. Every single combat activity by an element at the lowest level will contribute to one or more of these primary combat processes. Every aggregated combat activity will likewise fit into one or more primary processes.

The primary combat processes, listed in Table 5, are either externally or internally directed. External processes (and only these) change the states of enemy elements; internal processes change the states of own-force elements, and do not affect enemy elements. Both types of processes occur over time during combat, each waxing and waning in intensity as the circumstances of combat change. At a fixed instant of time, most or all of the processes will be ongoing for each side across the structural panorama shown in Figure 7. Combat processes apply to both sides, although the effectiveness of their application can differ markedly for the two sides.

Table 5. Primary Combat Processes

EXTERNALLY DIRECTED PROCESSES	INTERNALLY DIRECTED PROCESSES
Demoralization	Motivation
Destruction	Command-Control
Suppression	Information Acquisition
Neutralization	Communication
Disruption	Movement
Deception	Protection
	Sustainment

As with the command-control function, the command-control process includes not only planning and decision-making by the command chain, but controlling actions by all other combatants. The information acquisition process entails acquiring information on both the friendly and the enemy force, as well as on the combat environment. Although acquisition of information about the enemy (intelligence gathering) has an externally directed aspect, the process is classified as internally directed because its purpose is to provide information to commanders for use in the command-control process. The communication process differs from information acquisition in that the latter involves reception of information while the former involves transmission of information. Protection is an internally directed process because its purpose is to preserve the friendly force from enemy action, rather than to harm enemy elements. Movement is a process that involves all actions changing the spatial location of own-force elements. Sustainment includes both materiel support and support to personnel. Motivation involves the mind and spirit of friendly force combatants. It is the opposite of the externally directed demoralization process, which acts against the mind and spirit of enemy personnel. The destruction process includes damage to materiel and the wounding of combatants, in addition to outright

destruction and killing. Suppression involves the reduced efficiency of combatants by raising fear of harm. Neutralization means that part or all of the enemy force is placed in a position where they are completely unable to support their mission. Disruption involves delaying or denying enemy execution of actions, including support activities. Deception works through the enemy's information acquisition process to his command-control process to misperceive the combat situation. The processes are explained in more detail in Chapter 7.

The relationships among actions, functions, and processes are shown in Figure 11, in which we use the notational convention of Figure 6. Five Blue force units are firing at five Red force units with the intended result of destroying all of them. Simultaneously, one Blue unit feints a maneuver intended to deceive a Red unit The actual results of the firing are two Red units destroyed and three suppressed. The actual result of the decoy maneuver is that one Red unit is

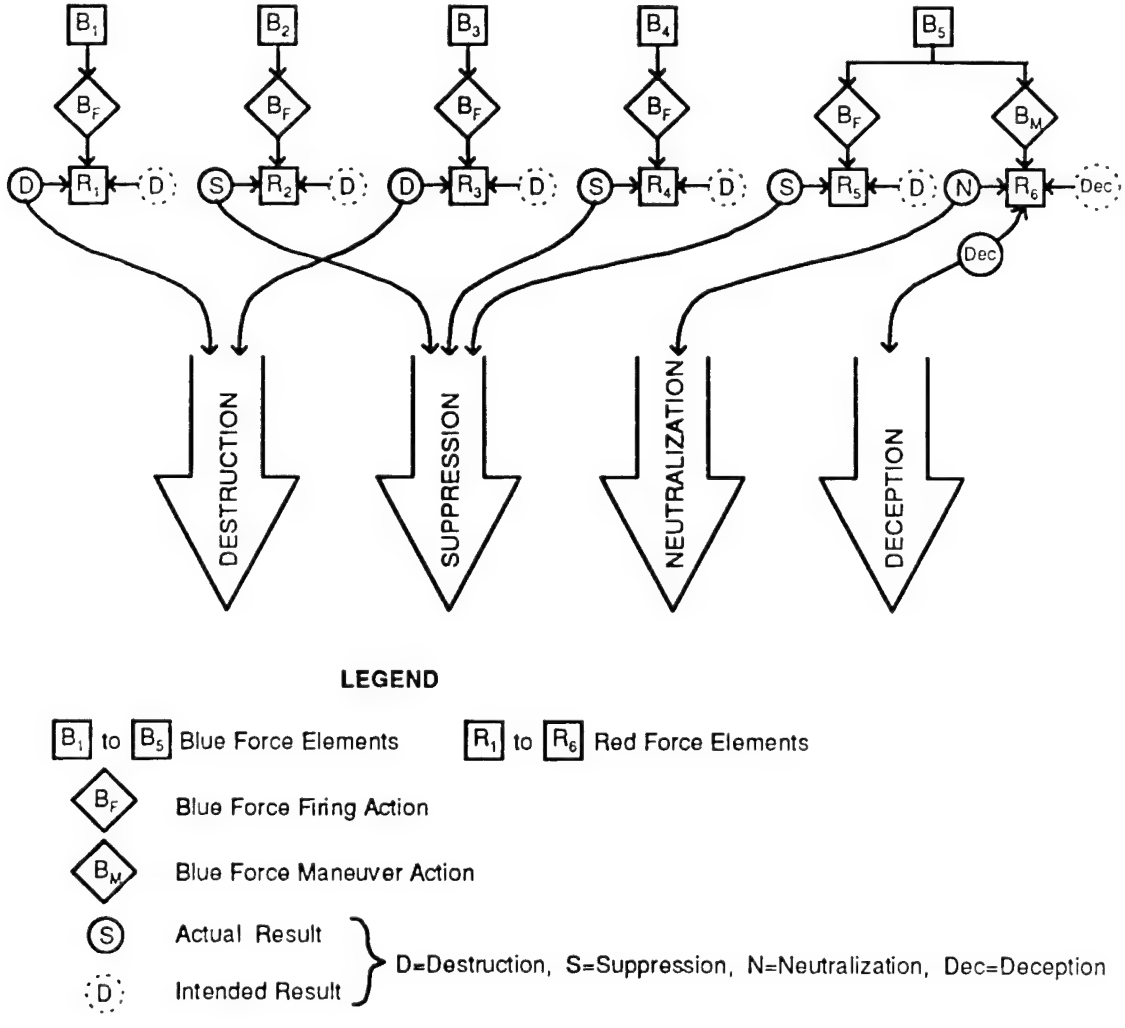


Figure 11. Relationships Among Actions, Functions, and Processes

deceived to the point that it moves to a position that isolates itself from the battle, and thus is neutralized. Firing and maneuvering are actions. A Blue force element firing against an enemy element with an associated intended result, is a combat function. The combination of (1) a Blue force element firing against a particular enemy element; (2) the enemy's simultaneous response affecting that particular Red Force element; and (3) the combat environment's impact on both Blue and Red force elements leads to the actual results that come out of all these interactions. This is a combat process. For simplicity, the Red force and combat environment impacts are omitted from Figure 11. The figure is further simplified by not showing all the results (and thus not all the processes) of a real engagement.

The firing and maneuvering functions shown in Figure 11 aggregate into separate collections of destruction, suppression, neutralization, and deception processes. The firing actions of Blue force B_1 and B_3 lead to the destruction process; those of B_2, B_4, and B_5 lead to the suppression process. In addition, B_5 contributes to the neutralization and deception processes through its decoy maneuver.

6.4.4 Some Observations on the Property of Aggregation-Disaggregation

In aggregating elements (with their attributes), actions, functions, and processes from the lowest level up to the highest level within the full combat environment, we gain a perspective of combat from the vantage point of those who participate in it. In doing so, however, we sacrifice detailed information about the states of individual elements, the actions they take, and the effects on the elements acted upon. At the lowest level, a clear input-output accountability conceptually exists for everything that happens in the combat arena. In moving from the lowest level to the higher levels of aggregation, we shift from discrete single activities to substantial interlinkage of aggregated activities. The interlinkage is not only within each force but also arises through interaction with the opposing force. The complexity is of such magnitude that precise tracing of accountability (while remaining possible in principle) becomes inordinately difficult. Although we have defined each process to be distinct from all others, aggregated processes as seen by combatants as an amorphous blend. The impact of one or two processes cannot be examined without considering all the rest. Combat processes, while providing us with a more orderly picture of what happens in combat, are dynamically related in degrees that vary with time and circumstances, as discussed in Chapter 7.

There is a further point to be made. The property of aggregation-disaggregation that we ascribe to combat elements, actions, functions, and processes is used in this document only in a static sense. We conceptually combine elements at a

moment in combat into units of larger and larger size, and combine actions such as firing and processes such as suppression into larger and larger agglomerations of firings and suppressions by larger and larger units. And conversely, we conceptually break down (disaggregate) elements, actions, processes, and so forth into smaller and smaller pieces at a point in time. But what we do not—and cannot—say is that anyone can predict how a group of single elements or ongoing elemental processes at any time during combat will be formed into any particular set of aggregated elements or aggregated processes at any later time. Nor can we say that an aggregated element or an aggregated process can be traced back in the past or forward into the future to any particular states of individual elements or to any particular processes affecting the individual elements. The aggregation-disaggregation properties we ascribe have no cause-and-effect accountability over time, and they are without predictive power.

In speaking of aggregations of "like" elements and "like" actions, we do not mean "precisely alike" elements and actions. We mean the aggregations that normally occur in military units and the aggregated actions those units normally take. Thus the aggregation of human elements into a platoon would include personnel trained with many different military specialties, and the aggregation of materiel elements would encompass a variety of equipment suited to the mission of the platoon. Included among the military specialties and equipment would be those for both offensive and defensive actions, for sustaining the unit, for communicating, for moving the unit, and so on. The "likeness" of aggregated elements and actions is related to what the unit is intended to do in combat; it is a functional likeness, rather than a literal one.

6.5 FROM ELEMENTAL RESULTS TO FINAL OUTCOMES

The problems encountered in the transition from the lowest to higher levels apply also in the transition from elemental results to aggregate results of aggregated processes, and to the cumulative aggregated results that are the final outcome of combat. At the bottom level, the results of element-action-element activities are distinct. At the level of aggregated activities, the aggregated results become so intermingled that identifying particular effects with particular causes is difficult or impossible. Each of the aggregated processes is composed of many micro activities that create micro results contributing to that process. The aggregated results from the complete set of primary combat processes are then blended into the full range of results across the combat spectrum at any point in time. Figure 12 (an extension of Figure 11) portrays this blending. As combat proceeds, the cumulative results lead to new combat situations, and at the end of combat, lead to combat outcome. At any moment in combat, the changes of state are going on not sequentially but simultaneously. The time intervals between

changes, Δt, are small (approaching zero), so that the combat situation from the overall view appears to be changing continuously.

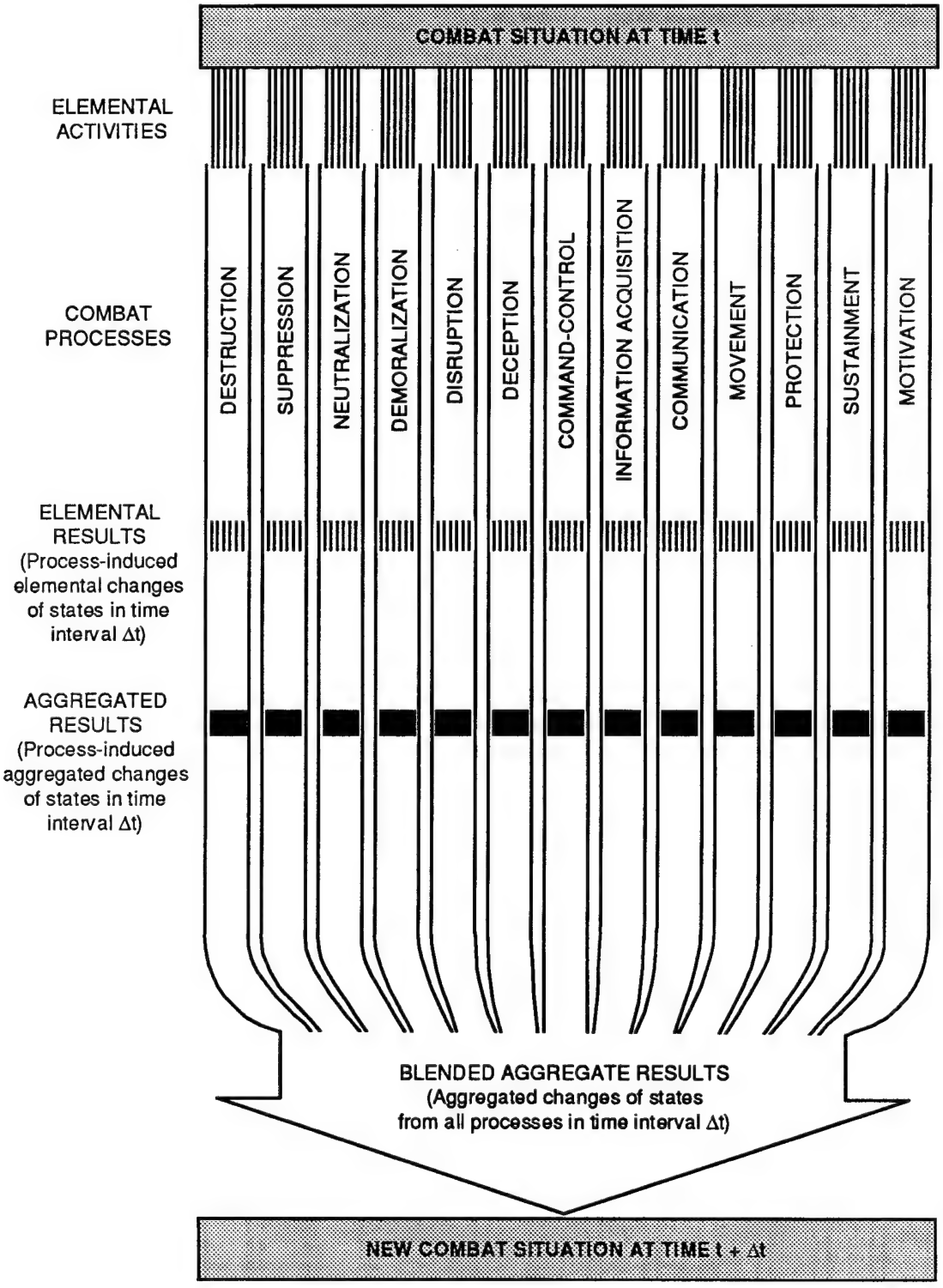


Figure 12. Blended Aggregation of Process Results

6.5.1 Combat Structure from a Fighting Perspective

Military combat involves primarily the psycho-physical act of fighting in order to achieve a mission. All other acts associated with combat support the act of fighting. Command and control gives purpose and direction to fighting, while support sustains it with substance, and information acquisition provides the means for good decisions. By analogy, at the elemental level, command and control is the brain and the nervous system, support is the nutrition and circulatory systems, and information acquisition is the five senses, all fostering the bone and muscle used in fighting to strike the blow and thrust the sword.

To further clarify the role of processes in combat structure, Figure 13 presents an enlarged view of the combat arena of Figure 7. The heavy line identifies the region of combat interaction. Within the region of interaction, the internally directed processes of each side directly affect the forces of that side, and the externally directed processes directly affect the forces of the opposing side. The internally directed processes affect the opposing forces indirectly by supporting the force elements that carry out the external processes. Both internally and externally directed processes are of equal importance; without the internal processes, the external processes cannot be executed. The internal command-control process, for example, is needed to set all other processes in purposeful action. Portions of the forces blocks are shown outside the combat interaction region because at any point in time, certain forces in combat may be performing functions that are not affected by interaction with the enemy.

All of the processes of each side are susceptible to being countered in some degree by processes of the other side. No process is free from the possibility of being countered.

6.6 COMBAT STRUCTURE IN THE TIME DOMAIN

Having examined the fixed-time structure of combat, it is now necessary to consider how these time-instantaneous slices are integrated over the time domain from combat initiation to combat termination.

6.6.1 Structural Invariance Over Time

Figure 14 illustrates how the introduction of time affects the overall structure of combat. The figure indicates that the external context variables for each side influence combat from beginning to end. The initial conditions set by the external context provide the starting boundary for combat, and throughout combat there can be continuing constraints and impulsions, as well as

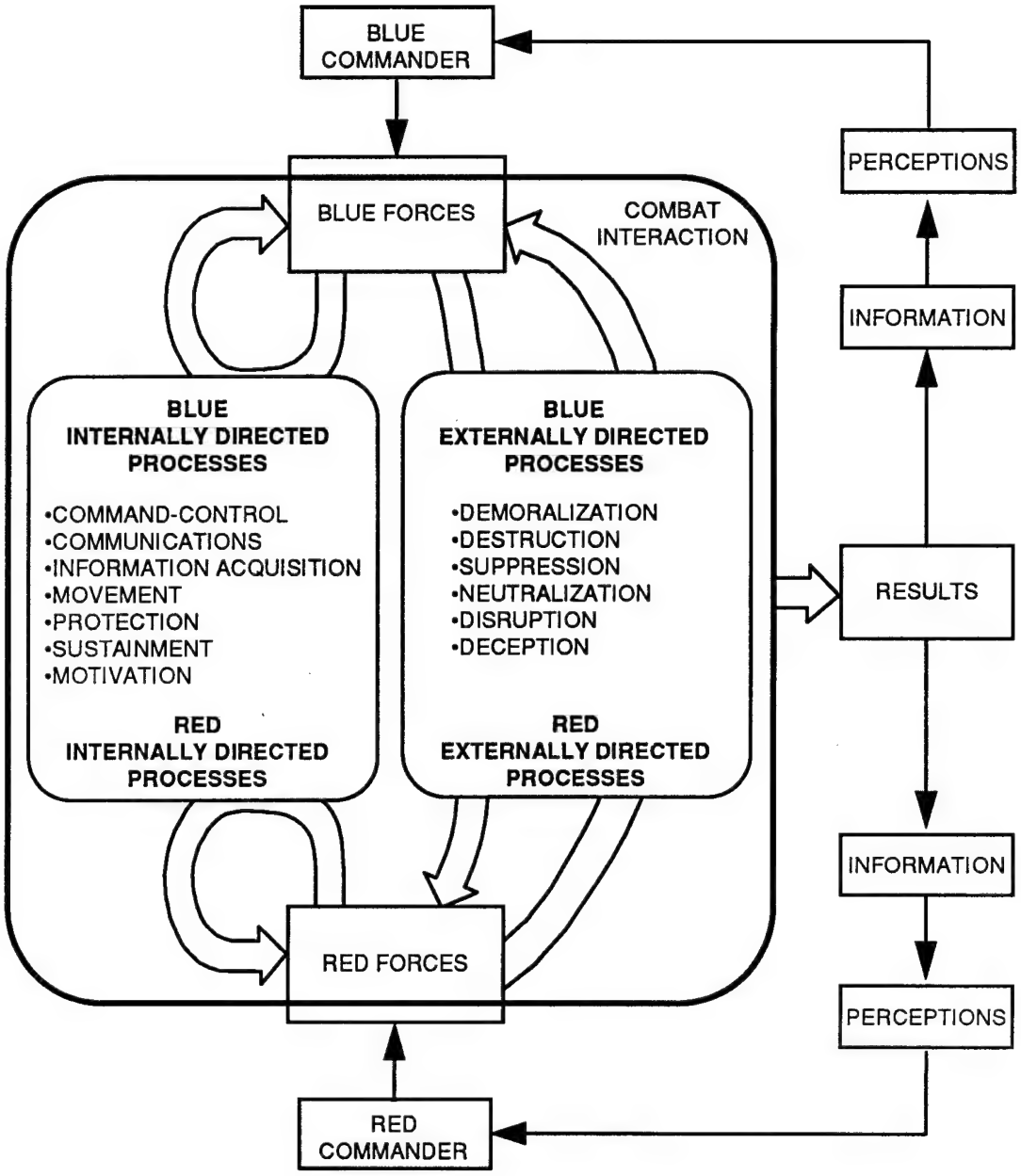


Figure 13. The Role of Processes in Combat Interaction

reinforcements into the combat arena and changes of mission directed from outside.

The fixed-time cross section of combat is a static, instantaneous picture; it is invariant with time. At every point in time (as, for example, $t = t_3$), the same symmetrical pattern of force and activity relationships pertains for the two antagonists, as do the hierarchical and lateral linkages with other forces. The

interdependent combat functions and the combat processes (neither are shown in Figure 14) do not vary in kind over time, but constantly vary in degree for each of the two sides. Thus combat functions and processes would not appear as pipes of constant diameter as time progresses, but as cylinders of expanding and contracting diameters. The processes are initiated by each side's actions but are affected by all three parties to combat.

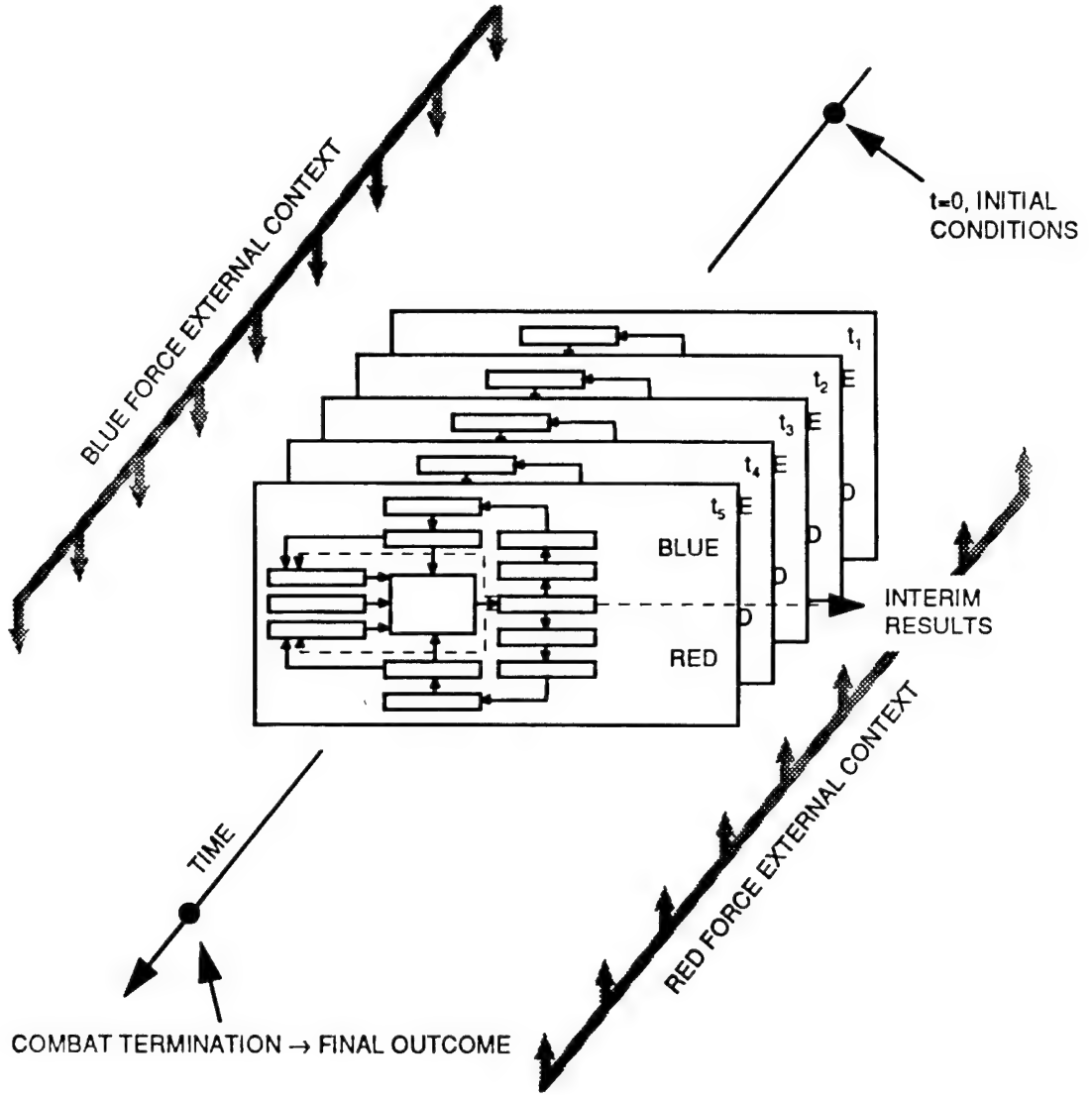


Figure 14. Combat Structure in the Time Continuum

All functions and all processes are potentially operable over any fixed-time cross section and their intensity and the degree of interaction among them will change over time with the dynamic interplay of opposing forces. Each of the snapshots of combat (shown in Figure 14 at times t_1, t_2, t_3, t_4, and t_5) represents the combat situation at that moment. At each time point, the combat processes are altering

the combat situation, leading to a new situation at the next time point, and so on to the termination of combat. Combat termination occurs after the active fighting by both sides ceases and the two sides disengage. The situation at this time is the outcome of combat.

6.6.2 Asymmetries Between Opposing Forces

The structural symmetry between the two adversaries—the same pattern of force and activity relationships, the same categories of combat functions and combat processes—is time invariant. However, functional symmetry in patterns and categories says nothing about symmetry of capability between the two sides. Beginning with the external contexts and the starting boundary conditions of the two sides, together with their missions, and continuing through all aspects of combat, every specific element, action, and state on one side will differ from every element, action, and state on the other side. Quantitative and qualitative differences will abound in forces and their attributes, and the differences will change as combat progresses. While both sides have the same categories of combat functions, each will use those functions in its own ways and with its own effectiveness, and the processes that derive from those functions will yield different results for the two sides.

How each side will fare in combat will depend on these differences and the dynamics of how effectively each side can convert its combat potential into realized capability for accomplishing the mission. The means for doing this is combat power, addressed in the next chapter.

Chapter 7

DYNAMICS: THE CONCEPT OF COMBAT POWER

7.1 GENERAL

7.1.1 The Transition from Structure to Dynamics

The transition from structure to dynamics marks a shift from the relatively straightforward to matters of complexity. Here we must pattern our approach more after the social and biological sciences than the firmer approaches of physical sciences.

Nevertheless, we have sought to be as scientifically objective as the state of knowledge permits. While military practice will undoubtedly remain much in the realm of art, our description of combat dynamics is not so much art as a holistic explanation of the workings of combat. We believe that, in principle, the dynamics could in the main be substantiated—quantitatively in many parts and qualitatively elsewhere—if the data of combat were somehow vastly expanded. For the present, we must be content to provide a descriptive explanation. The subject is presented more as a source of insight than as an explanation with predictive power. Poincaré, addressing the difficulty of expressing solutions to problems, stated, "What we can always do, or rather what we should always try to do, is to solve the qualitative problem so to speak, that is to try to find the general form of the curve representing the unknown function."

7.1.2 Combat Power, Processes, Distribution, and Output

The concept of combat power is central to understanding the theory of combat. Axiom 4 states that commanders create combat power from combat potential in furtherance of a mission. It is combat power that produces results in combat.

We begin the discussion of dynamics by explaining the meaning of the term combat power as used here. Each side brings energy to bear in the form of combat functions with the aim of creating combat power, but it is only through the fundamental processes of combat that combat power is actually produced and results achieved. As stated in the previous chapter, the results of combat processes are not determined by each side unilaterally; they are formed by the interactions of the two sides, as further modified by the combat environment.

Commanders and their forces are judged by how well they distribute the combat power developed and how successfully they vector that power toward mission fulfillment. The cumulative effect of combat power over time is called *combat output*. This corresponds to the work done in trying to accomplish the mission in the face of enemy opposition. It is the combat output of one side relative to the combat output of the other side that determines which side has done better at the conclusion of combat.

7.2 THE NATURE OF COMBAT POWER

Combat power has different meanings to different audiences. An explanation of the term as used here is presented below.

7.2.1 Characteristics of Combat Power

Combat power, the agent by which results are achieved in combat, is the means of translating the purpose of combat into the desired outcome. The combat functions of each side are unilaterally applied to remove the enemy's opposition and to achieve mission fulfillment. In the resulting interactions between the two sides and the combat environment, combat processes, reflecting actual results, form the combat power achieved by each side. Since combat power derives from the basic components and structure of combat, it inherits their characteristics and translates them into the dynamics of combat. Thus, such properties as vectored control and aggregation-disaggregation, described earlier in the static sense, carry over to the dynamic nature of combat power.

Although combat power cannot be seen any more than can gravity its results can be observed, and in some degree measured. It is very real to commanders in combat and to every combatant. Like a force field, combat power does not exist as a single entity such that each side has a lump sum of combat power that is applied against the other side's lump sum. It is a distributed quantity that is continuously being formed and aggregated (from finite bits) throughout the combat area, waxing and waning here and there as the battle progresses. Each side forms and distributes its own combat power, but it cannot do so unilaterally, for its combat power is affected by the opponent's actions and by the combat environment.

Definition of combat power. **Combat power** is *the realized capability of a force at any instant of time to achieve results in combat in furtherance of a particular mission against a specific enemy force in a specific combat environment.* Combat power is the actual instantaneous capability brought to bear in any manner that influences the combat situation. It exists as elemental combat power contributions that can be aggregated and distributed in time and space by command and control actions.

Combat power encompasses capabilities that are both internally-directed (affecting the friendly force) and externally-directed (affecting the opposing force). It does not depend unilaterally on the actions of a force, but rather on the combination of those actions and interactions with the opposing force and the environment. Because of this, the results of combat power are not necessarily the useful results expected by one side taking an action, but instead are the actual results that occur in the amalgam of both sides taking action, each for its own purposes.

Combat power directly impacts elements, not actions. As with the element-action-element activities described in Chapter 5, combat power is brought to bear both on physical elements (tanks, trucks, aircraft, fortifications, ships) and cognitive elements (commanders, other personnel, the fighting spirit of individuals). It does not directly affect actions (shooting, moving, firing, feeding, and so on), but actions are impacted indirectly through the combat power effects on elements.

Vector characteristic. Since combat power is the means of realizing intentions, it has the nature of a directed agent. The combat power of each side is directed toward the accomplishment of that side's mission, and thereby operates as if vectored to achieve the mission. But since each side's combat power is affected by the opposing side and the environment, the vectoring does not guarantee that results will align with the vector. In addition, vectoring can be weakened by ineffectual internal activities of the friendly force, and friendly and enemy activities external to the combat arena can impinge on the vectoring by each side.

Trilateral dependence. Combat power is generated from available combat potential. But whereas the combat potential available to each side is unilaterally dependent on the actions of that side, the resulting combat power is dependent on the actions of the enemy, as well as those of the friendly side, and in addition is affected by the combat environment. The trilateral dependence of combat power is fundamental.

Granular characteristic. The ebb and flow of combat power on each side may appear to be a continuous function, smoothly changing over time. Actually, combat power is granular; it is composed of minuscule "grains" of combat. Viewed at the micro level, combat power would exhibit countless ebbs and flows, ups and downs. We say "countless," but the number of grains is finite nonetheless. The bits of combat power come from the great many individual element-action-element couplings that combine to give the appearance of continuously flowing activity. Each granule contributes its share to combat power, and in this sense, the contributions can be thought of as akin to the quanta of quantum mechanics. Combat power is granular in time and in the three dimensions of space, even though it appears in the macro view as

continuous. Yet, while remaining faithful to the micro granularity, the theory must address the aggregation of grains of combat power into the amorphous-appearing nature of combat dealt with by combatants in battle.

An instantaneous quantity. Combat power acts as a rate. It is the capability to achieve results at any instant of time, and thus it is seen as the time rate of change of the states of elements (own force, enemy force, and environment). At the lowest level, it is the capability to achieve results at a particular granular element of space at one instant of time At the overall level, it is the aggregate capability over many elements of space at one instant. The cumulative impact of combat power over time is produced as combat output.

Property of aggregation-disaggregation. Another characteristic of combat power is that elemental combat power contributions can be aggregated into clusters of combat power, and these in turn into larger clusters. Conversely, combat can be dissected into smaller groupings of combat power and on down to elemental contributions. This property derives from the corresponding property of elements and actions.

Combat power exists only during combat. Combat power exists only in the face of an opposing force while combat is in progress. Before combat commences and after it terminates, the capability to achieve combat results exists as combat potential, not as combat power.

Combat power exhibits self-similarity within the hierarchical structure of combat. Combat power works at the lowest echelons of combat in the same way it works at the highest echelons. This is determined by the fractal-like hierarchical character of combat structure. In principle, the combat power of a tank brigade is exerted in the same manner as the elemental combat power exerted by a single tank.

7.2.2 Combat Output

Since combat power causes a rate of change of state, its effect acting over time is cumulative changes of state, which we call combat output. **Combat output** is *the cumulative results (measured as the new states of elements) of combat power acting over time on the combat situation.* Combat output is simply the time integral of combat power. It is equivalent to combat work accomplished against an enemy and in furtherance of a mission. It differs from the physics definition of work in that much of combat work is cognitive in nature rather than physical. As with combat power, combat output is not necessarily fully useful to either side. It can be favorable or unfavorable depending on how well it advances the mission. The combat power results being integrated as output are those actually occurring

because of the combat power applied by both sides (as distinguished from results perceived by each side to be occurring).

7.2.3 Definitions of Terms Related to Combat Power

The following definitions stem from the nature of combat power and combat output, and from the axioms set forth earlier.

Combat result is *the changed state that occurs in a single or aggregated element from an elemental or aggregated combat activity.* The new state is the changed condition of the single or aggregated element being acted on as reflected by its attributes, including its spatial conditions. One possible combat result is destruction of an element, in which the state change is from existence to nonexistence (the state change for a truck that has been destroyed but whose parts are salvaged is nonexistence as a truck element plus conversion of the truck into separate truck parts elements).

Combat situation is *the totality of the states of both sides and of the environment at any point of time during combat.* "Totality" means the aggregation of the states of *all* elements. The combat situation is the reality of what exists in the combat arena, not what is perceived to be the situation by each side. The combat power mixture of the two sides produces a rate of change of the combat situation at any instant of time. Combat output produces accumulated change of the situation over time.

Designed combat potential is *the pre-combat latent designed capacity of a force to achieve useful results in combat when organized, trained, equipped, supported, motivated, and led according to the force design against a design threat.* Designed combat potential represents a nominal state of combat capacity unencumbered by shortfalls in combat readiness and undegraded by enemy action. It is a unilateral characteristic of a force rather than one that is influenced by the actions of a particular enemy in a particular combat environment.

Available combat potential is *the latent capacity of a force to achieve useful results in combat with its existing organization, training, equipment, support, motivation, and leadership.* This represents a combat capacity taking into account real-life shortfalls, but as yet undegraded by a particular combat environment or by enemy action. Immediately before combat commences, available combat potential is what each side has to draw on for conversion to combat power. During combat, potential not yet converted to combat power remains as available potential. Because of degradations from enemy actions and the environment, available combat potential is rarely, if ever, transformed fully into combat power.

Combat energy. Although the term "combat energy" has not been given a particular definition, energy in the broadest sense of the word is what is expended to produce combat power and combat output. Specifically, energy is expended by each side in performing combat functions to create combat power by means of the processes formed in the three-sided interactive mix. The human energy expended is both physical and cognitive. The material energy is in the form of expenditure of fuel, ordnance, and other consumables, and overcoming impediments of the combat environment.

7.2.4 A Mathematical Analogy for Combat Power

Granting questions about the validity of using mathematical expressions to characterize a subject as complex and as subject to the human element as combat, it may nevertheless be useful to try to express the essence of combat power in mathematical analogy. This may help in understanding the subject, and, if nothing else, the attempt may test the concept by trying to state it in mathematical terms. Beyond that, some ideas may begin to take shape for further exploration.

We begin by setting down some terms.

Let $\vec{P}$ represent combat power. The notation $\rightarrow$ signifies that combat power acts in the manner of a directed vector. In keeping with the definition of the term, $\vec{P}$ is combat power at any instant of time. Its effect is observed as the time rate of change of the states of elements.

N represent the number of combat elements, which include humans and material things.

α represent the combat value of attributes embodied in the elements.

$\vec{u}$ represent the time rate of actions being taken by combat elements to achieve results. The notation $\rightarrow$ signifies that the actions are directed with the intention of furthering the mission and in this sense act as if vectored.

Then (αN) represents state at a specific time (the combination of elements and their attributes).

Let subscript B stand for Blue force, and
subscript R stand for Red force.

Then, as a first step, in simplest terms we can express the generalized concept of combat power (in part) as:

$$\vec{P}_B = f\left[(\alpha N)_B, \vec{u}_B\right] \quad \text{and} \quad \vec{P}_R = f\left[(\alpha N)_R, \vec{u}_R\right]. \tag{1}$$

In these equations, f stands for "a function of." We do not know the nature of that function, except that it involves elements, attributes and actions and is conceptually the same for both sides. The simplest form the function f might take is the product of αN and u, but the function is almost certainly more complex than this.

But Equation Set (1) cannot represent the complete notion of combat power, since, by our definition, the combat power of each side is modified by the opposing force's combat power, and so an expression must be included to reflect this. The enemy combat power can impact only elements (not actions), and in impacting elements, it will change the attributes of those elements, thus changing the state of the elements. Therefore we postulate the instantaneous changes of state in the following expressions:

$$\frac{d(\alpha N)_B}{dt} = g\left(-\vec{P}_R, \vec{P}_B\right) \quad \text{and} \quad \frac{d(\alpha N)_R}{dt} = g\left(-\vec{P}_B, \vec{P}_R\right). \tag{2}$$

In Equation Set (2), g again stands for "a function of." And again, we do not know the nature of this function except that it is conceptually the same for Blue and Red forces and is different from that represented by f. We also make the assumption that Red combat power, $\vec{P}_R$, has a negative effect (as indicated by the minus sign) on the change of state of Blue forces, while $\vec{P}_B$ has a positive effect, and the converse is true for the change of state of Red forces.

Equation Sets (1) and (2) are cross-coupled (or conjugate) equations, exemplifying the interaction of the combat power of the two sides. The state term in the equations (αN), acting through the time rate of its actions, $\vec{u}$, produces combat power, but the state term is continuously modified by the combat power of the enemy. To refine this notion more carefully, we mean that at the micro level, every individual element with its attributes that acts against an object element produces a quantum of combat power that is seen as the rate of change of the object element's attributes (hence its state), but that quantum is affected by the (virtually) simultaneous actions of enemy elements that also impact that particular object element.

In ground combat the effects that act to reduce the term N (these are solely the result of the destruction process) are generally less than the effects that adversely affect attributes (α). Thus processes that affect α but do not change N, such as

suppression, demoralization, deception, and disruption, generally have a more important influence in reducing enemy combat power than does destruction.

We do not know how the elemental bits of combat power (as affected by elemental bits of enemy combat power) can be rigorously combined into aggregated combat power. We assert that the summation process is not linear; that is, aggregated combat power is not the arithmetic sum of elemental bits of combat power. Granting the lack of a methodology for aggregating, we nevertheless suggest that conjugate Equation Sets (1) and (2) can be considered as a mathematical analogy for the concept of combat power at both elemental and aggregated levels of force.

7.3 DEVELOPMENT OF COMBAT POTENTIAL

Axiom 3 states that combat potential, the latent capacity to achieve results in combat, is embodied in military forces. Prior to combat, forces are organized, prepared and indoctrinated, sometimes hastily and sometimes over many years, with the potential to carry out combat when called upon. The development of combat potential begins when raw manpower is recruited, material is turned into weapons, and doctrine and tactics are developed. It continues with training, preparing, and developing readiness until the latent capacity is activated and discharged during combat. While combat is under way, forces outside the combat area not engaged in combat retain their combat capacity as combat potential, and the capacity of some of the forces within the combat arena may also be retained as potential. Once combat has terminated, residual capacity reverts to combat potential.

7.3.1 Distinction between Combat Potential and Combat Power

The dividing line between combat potential and combat power is determined by the question of influence. If an element, regardless of location, exerts any influence on the combat situation, it is contributing to combat power. If not, it remains combat potential. For example, a strategic intelligence acquisition system available outside the combat area has combat potential, but if it feeds in tactical intelligence about the combat situation, then it contributes to combat power. If a unit within the combat area is held in reserve, it nevertheless contributes to combat power, since its availability influences the force commander and his subordinates in their decisions (and may also influence the opponent if he is aware of the reserve unit). Similarly, reserve stocks of ammunition and fuel available to each side have an influence because, if stocks are ample, commanders know that their combat actions will not have to be limited; or, if stocks are low, they know the force will have to curb combat action to hoard supplies. An infantryman who participates in heavy combat action but

never fires his rifle contributes to combat power because his presence affects those around him. In all these examples, however, most of the capacity of the reserve unit, the unused portion of reserve stocks, and the infantryman's capability remain as combat potential.

The extent to which any particular unit may be counted as potential rather than combat power is not significant in itself; the influence on the situation is the significant point. The difference between combat potential and combat power is analogous to the difference between potential energy and kinetic energy in physics. In physics, work can be accomplished by converting potential energy to kinetic energy; in combat, work (combat output) can be accomplished by converting combat potential to combat power. Combat potential is latent capacity, while combat power is active, realized capability.

7.3.2 From Designed Combat Potential to Available Combat Potential

Designed combat potential is a nominal potential based on how a force is designed and the environments and threats it is designed to be used against. The force's potential for use in combat situations different from the intended environment and threat will vary, usually on the down side. Its potential for achieving results in combat can be estimated by considering the numbers of force elements and the quantitative and qualitative characteristics of the elements based on both hard and approximated data (subjective to some extent) and various methods of computing force effectiveness against a specific or generic threat. Weapon effectiveness is usually based on laboratory tests, field tests, simulations, maneuvers, and past combat experience using the weapons. The effectiveness of individuals and units is based on similar data sources. Yet even with voluminous data, determining the combat potential of a force is difficult; there is no widely accepted method for summing the combined capability of all force elements. Extrapolation from experience remains the most reliable input to such estimates. Designed combat potential thus represents an estimated nominal capability that does not take into account particular force readiness degradations, nor degradations from the actions an enemy might take or an unfavorable combat environment might impose.

Available combat potential, on the other hand, incorporates all the real-life degradations to which a force may be subject. These can include poor leadership, inadequate training, low morale, fatigue, equipment in poor repair, inoperative communication links, shortfalls in manning and equipping, deficiencies in tactics and doctrine, and countless other exigencies. It is with its available combat potential that any force starts into battle. Before combat a commander has opportunities to improve his potential, but when combat commences, his available potential is what he has to draw on. Available combat potential is his

to unilaterally mold, but once combat has begun, the combat power he is able to activate from that potential will depend not only on his choices but also those of his opponent.

7.4 ACTIVATION OF COMBAT POWER FROM COMBAT POTENTIAL

As stated in axiom 4, commanders activate combat potential to develop combat power in furtherance of their mission. Activation of combat power begins during the preparatory steps at the outset of combat and intensifies during its course, with residual capability reverting to combat potential when combat terminates.

7.4.1 How Combat Power Is Activated

During the preparatory phase, combat energy is developed unilaterally by each side through the combat functions needed to initiate the mission. Preparatory actions include issuing initial orders, positioning forces and supplies, and observing the opponent. At this stage, the development of combat power from combat potential is largely unencumbered by enemy action. Thereafter, during the active phase when combat functions lead to interaction with the enemy, the combat power that a force generates is degraded from its potential by virtue of the enemy's actions in opposition and by any disadvantageous aspects of the combat environment. Figure 15 illustrates the degradation of combat capacity from designed potential to available potential to the capability to achieve results during the course of actual combat.

Activation of combat power is initiated solely through cognitive actions. The force commander on each side takes various command actions, primarily using the processes of command-control, motivation, and communication, to vector and control his force to accomplish his mission. Subordinate commanders extend the command function and the same processes throughout the force. Noncommand personnel respond to commands with countless cognitive decisions of their own to get their parts of the operation going, and these noncommand decisions further extend the vectoring and controlling. Thus the activation of combat power results from innumerable cognitive actions by all individuals in combat. The process of command-control operates through all individuals, though it is manifested as a top-down process initiated by a single combat commander. This extended process of command-control obviously is subject to inefficiencies (seen as friction, to be discussed later) as it stretches farther from the combat commander.

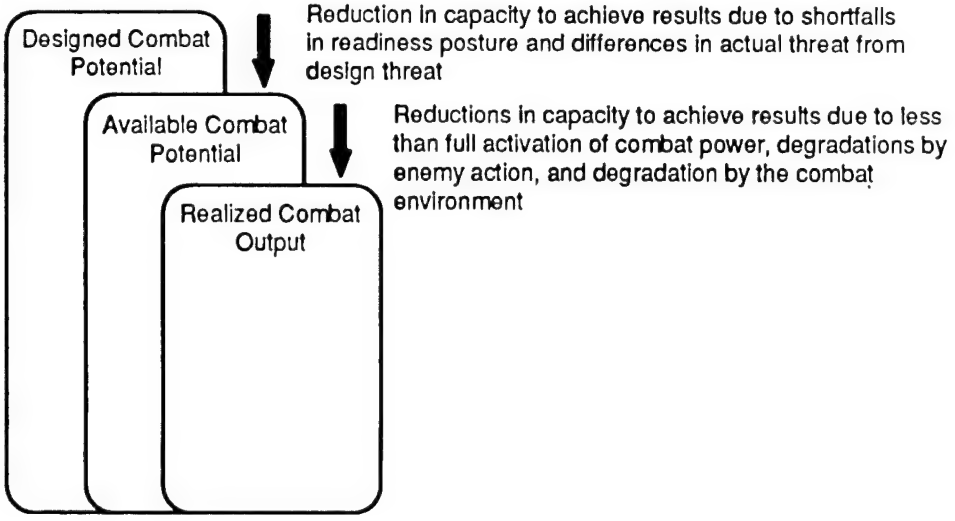


Figure 15. From Combat Potential to Realized Combat Output

In addition to this array of direct cognitive actions, there are many cognitive actions that fall under a preprogrammed class of automatic response to situations. These stem from training, indoctrination, culture, and ordinary good sense of what needs to be done. In a well-trained unit, a commander may state an order in only a few words. The unit takes over and knows the many things that must be done. At every decision node, innumerable actions are taken because of the vast built-in comprehension of what is wanted. The implicit content of the control system far outweighs the explicit content. The cognitive states of individual combatants have had inculcated in them the knowledge, information, understanding and motivation that vectors their decision actions properly, for the most part. A unit that makes such automatic responses correctly is described as well trained and as having cohesiveness and force integrity.

7.4.2 Negative and Positive Influences on Combat Power

Creating combat power from potential is subject to the faults mentioned previously that can arise in the extended control mechanism. A multitude of other factors can also have negative effects. The combat environment can be a major degrading factor. Severely adverse weather and terrain, for example, can greatly reduce the effective power activated from potential. Likewise, constraints imposed by higher commanders or by local conditions (such as interference from noncombatants in the area) can curtail the activation of power. Uncertainty about the situation can lead to faulty judgments. Chance events can have an impact.

On the positive side, given a particular level of combat potential, the activation of power can be enhanced in many ways. When a force is properly organized for

a particular combination of mission, situation, and environment, a kind of combat power synergy results. High morale, force integrity and cohesiveness are enhancing factors. Commanders, starting with the force commander but also including the rest of the command chain, have a paramount effect, for good or for bad.

Some of the most critical positive and negative influences are discussed below. The influences pertain both to the activation and the subsequent application of combat power.

7.4.3 Friction in Combat

A major degrading influence on combat power is what has been described as "combat friction." It appears to be ubiquitous, but its cause is only vaguely explained.

Defining combat friction. When applied to warfare, the term friction can have a variety of meanings. Among these is use to denote what might be considered the "grand friction" of war: friction that arises in the conduct of campaigns, in theater-level actions, and in national and coalition war activities. Clausewitz has used friction in this broad sense. We are concerned in this document only with the narrower significance of friction in combat.

Combat power often appears to be reduced due to causes that cannot clearly be laid to enemy action nor to own-force deficiencies. The cause of this reduction can be called combat friction. It is desirable, however, to limit as finely as possible what is included under the rubric "friction," avoiding the temptation to lump all manner of elusive factors that cannot easily be explained or quantified within a catch-all bucket called friction. Nevertheless, because understanding of the phenomenon is as yet nebulous, a degree of arbitrariness is necessary as to what is counted as friction and what is not. Friction is defined and described here conceptually rather than explicitly.

We define **combat friction** as *unproductive energy expended on any wasteful result that occurs when an agent element carries out an action impacting an object element. In the aggregate, combat friction is the summation of wasteful results occurring from many elemental actions.* Every element-action-element activity has associated with it not only an intended useful result, but possibly also an unintended, nonuseful, friction result, and these in combination lead to combat friction within a force.

A theoretical basis for combat friction. In accordance with the definition above, friction in combat arises from the countless interactions that occur among combat elements. The results are similar to encounters between physical objects: when one physical object strikes another, there is a wasted loss of energy, or more

precisely, the conversion of a portion of useful energy into nonuseful energy. The kinds of energy waste in combat are more complex than those in the world of physics, however, since human as well as material elements are involved.

Interaction between any two combat elements of the same force can result in friction. Every pairing is a potential source. This notion of friction is more easily seen in regard to pairs of single elements (such as two individuals or a truck and the mud it is driving through), but by extension, we can consider the friction between aggregated-element pairs (such as two platoons or the operations staff and the logistics staff of a headquarters). Friction may, of course, also result from an element taking an action that interacts with many other elements.

Friction only occurs as a byproduct of activity. It is the action that takes place in the element-action-element pairing that results in friction. Elements on the battlefield not taking any actions at a given time are not causing friction at that time. Whenever and wherever they act, there may be friction.

Combat friction is internal to a force, not the direct result of enemy action. We say this because friction is associated with the elements that are taking actions. When an element of one force takes an action that impacts an enemy element, that enemy element will, in response, often take actions that are wasteful, thus producing friction internal to the enemy force. One aim in combat is to magnify the opposition's friction, and even when this is not a specific intent, activities effectively directed against the enemy will inevitably lead to increased friction within the enemy force.

Sources of friction. The sources and results of friction are extremely varied. They are best described through illustrations:

> One individual gets in another's way as both try to fire on the enemy. Similarly, one battalion impedes another during a maneuver. Refugees fleeing the combat area interfere with fire missions. In all three cases the impeding results of the movements are friction.
>
> An order is written in an ambiguous manner. The result of the lack of clarity is friction.
>
> An order is garbled in transmission. The act of garbling has created friction. If the recipient of the garbled message takes action to find out what the correct order is, the effort lost in doing so is additional friction. If the recipient acts on the garbled order as he interprets it, he may or may not be causing more friction; to the extent that his actions lead to wasted results, he is causing further friction.

A clear order is received but incorrectly interpreted. The result of the cognitive action during which misinterpretation occurred is friction. The results of follow-on actions based on the misinterpretation will add more friction.

A muddy battlefield delays the maneuver of a force. The retarding action of the mud causes friction (in the physics sense as well as combat friction). Friction can occur from many kinds of interactions between elements of a military force and the physical environment.

A unit has been fighting with virtually no rest for three days. The reduced unit effectiveness due to fatigue is friction. The unit experiences aggregated friction losses of many kinds as elements of the unit take wasteful actions (the elements are primarily personnel taking faulty cognitive actions, but worn equipment can also lead to wasted results).

Two units fire at the same target. One of the two engages successfully. The wasted fire by the other unit is friction.

A unit advancing in an otherwise well-executed attack does not perform well because visibility is limited by smoke and dust. The reduced effectiveness due to obscuration is friction.

A force in the midst of combat receives a change of mission. The many changes in orders, deployments, and other activities will cause friction losses of many kinds.

An artillery unit executes suppressive fire against a force. The suppressive fire is not itself a source of friction within the force receiving the fire, but actions taken by the receiving force will entail friction losses to the extent that the force, being suppressed, takes wasteful rather then effective actions. This illustrates how actions by the enemy are not direct sources of friction within a force, but lead indirectly to friction.

In all these examples, the actions described have led to a partial loss of combat power because of nonuseful results. This is combat friction.

To generalize the many sources of combat friction, we can say that friction arises from inefficient and disorganized activity, redundant activity, damping effects of the combat environment and other constraints, wear and tear and fatigue in individuals and materiel, and (perhaps most important) faults in the functions of command, control and communication. We can also say that most of the causes of combat friction are amenable to reduction.

Quantifying Friction. From the concept of friction as the wasted results of countless elemental activities in combat, it follows that the more activity, the more friction. Moreover, it is clear there is a proliferation of friction because the wasteful action of one element can result in friction in the follow-on actions of several affected elements. This observation parallels that seen earlier in the structure of combat, where we saw a compounded cascading of combat activity as the number of element pairs increased with increase in force size. We are led to the conclusion that combat friction increases in a non-linear manner as force size increases. In other words, the number of instances of friction arising in a division-size force in combat is disproportionately greater than in a brigade-size force.

There seems to be no way at present to quantify the many kinds of combat friction, but it is a good thing to try. The effect of particular sources of friction will undoubtedly vary widely from case to case. Nevertheless, it appears that many sources of friction can be identified in general terms, and means to ameliorate adverse effects can be addressed. It will be worth investigating whether the gross effect of friction—the total loss of combat power from all sources of friction—could be quantified in some manner for forces of, say, battalion and larger size where the various friction effects may average out. If gross friction can be quantified in some degree, then we can begin to calculate average or expected values.

Any reduction of friction losses is to the good. Even though quantifying friction may be an elusive goal, study of the sources and ordering them by degree of seriousness appears worthwhile. Identifying which sources are conducive to reduction can provide a basis for minimizing friction losses.

The prior discussion of combat friction points to a theoretical basis for compounded losses in combat power due to friction as force size becomes larger. The amount of loss may well be substantial, as suggested by Trevor Dupuy in *Understanding War*. The following discussion summarizes a hypothetical qualitative tool for envisioning the extent by which friction losses aggregate.

If every element in a force were causing friction by impacting all other elements of the force, then the upper limit of friction losses would be proportional (approximately) to the square of the number of elements in the force. But, since each element cannot impact all other elements, nor can every impact be expected to result in significant friction, we can say that the friction losses should be proportional to the number of elements actually causing friction raised to a power between 1 and 2 (because not every element causing friction will interact with every other element). In equation form, the friction losses would be:

$$\Phi_N = \frac{1}{2}\phi n_f^x \tag{3}$$

where Φ_N is the loss in combat power due to friction in a force of N elements.

ϕ is the average loss of combat power due to friction in each element-action-element pairing where friction occurs.

n_f is the number of elements causing friction at any instant of time, a number probably substantially less than N.

x is an exponent between 1 and 2.

With our present limited understanding of combat friction, this equation can do no more than indicate the exponential compounding of friction as force size becomes larger. If it were possible to estimate average friction losses per combat interaction, or to determine that most friction losses come from only certain kinds of interactions, then a quantitative approach might become more tractable.

Figure 16 shows how combat power loss due to friction changes as force size increases. The magnitude of combat power friction loss in the figure has no quantitative significance except to demonstrate the compounded increase as force size increases.

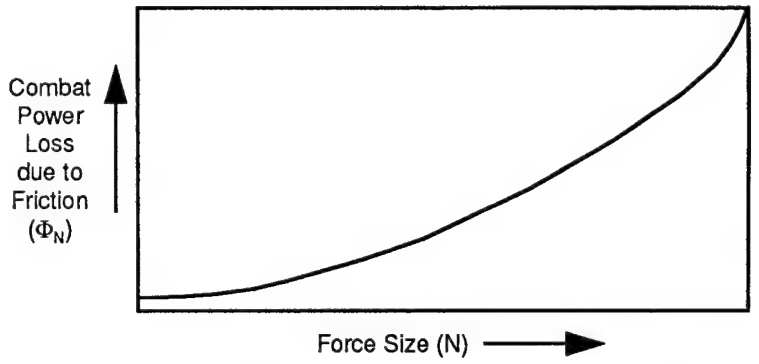


Figure 16. Combat Power Loss Due to Friction

Conclusions. It is clear that combat friction, as defined herein, is a widespread phenomenon on the battlefield. Considering the variegated sources and likely frequency of friction, the following are advanced as general conclusions:

- The source of combat friction lies in the wasteful results from the activity of individual force elements. The more activity in a force, the more friction.

- The effect of combat friction on combat is substantial, is widespread, and is adverse to the side incurring the friction.

- The amount of friction, and hence the degree of adverse effect, increases in a compounded manner as force size increases.

7.4.4 Enhancement of Combat Power Through Combined Arms Synergism

Military forces are organized in a multilayer hierarchy of units, each unit composed of two or more smaller units. In this way, forces (and hence combat power), are aggregated into larger and larger sizes. A crucial point is the manner in which combat power aggregates as force size increases. As the hierarchy of forces is built up from individual elements, can the combat power of the aggregate force be taken as the sum of the combat powers of the elements of the force, or is there some other basis for summing combat power? In a linear theory, it is conceptually possible to add the separate parts to get the whole. But combat in no sense conforms to a linear theory; it is a dynamical, nonlinear phenomenon, with a multiplicity of cross-connected factors within and between the two opponents. Summing the separate parts does not give the whole, nor does summing the combat power contribution of the separate parts lead to the combat power of the whole. We have already noted the compounding of friction losses as forces become larger.

Synergism from mutual support and reinforcement. To approach the problem of aggregation, we first consider a hypothetical force composed entirely of like elements. The only such forces today would be small units, such as a platoon of identical tanks or a flight of identical aircraft. In ancient warfare, one can picture larger forces of like elements—perhaps hundreds of warriors all trained alike and armed with identical spears, daggers, and shields. In a battle where each warrior fought independently of the others (in a melee, for example), the combat power of the aggregate force might well be the sum of the combat powers of all the individual warriors (disregarding friction).

If we combine the actions of individual warriors tactically in a phalanx that operates in a concerted manner, the combat power of the aggregated force then appears (from historical evidence) to be greater than the sum of its parts, since it can defeat a same-size force not organized as a phalanx. The explanation lies in the mutual protection and reinforcement (physical and psychological) that each warrior now receives from nearby warriors when operating in unison as a phalanx. Combat power synergy has resulted from a tactical improvement. Clearly, where there is mutual reinforcement and protection in a force, the aggregate combat power of the force is greater than the sum of the combat power of the elements of the force.

If, however, this homogeneous mutually supporting force comes up against a force of equal size that not only employs mutual support but also has a greater variety of weapons (some of the warriors, let us say, armed with longbows and arrows instead of spears and daggers), the homogeneous force can now be at a disadvantage if it is vulnerable to any of the new weapons. Any single weapon system, even though powerful when standing alone, may be defeated if it cannot defend against all opposing weapons (in the example case, stand-off use of the bow and arrow). The point applies as well to a force using a single tactic against an equal-size force using a variety of tactics. By further extension, the point also holds even where a disparity exists in the capabilities of similar weapons. These cases exemplify, in simple form, the concept of combined arms. The term is used here in the most general sense of combination both within a single military service and across service lines.

Depending on how vulnerable it is, the side deficient in weapon or tactical variety can be outweighed in combat power by an opponent inferior in force size. There comes a point, however, where the sheer magnitude of the weapon-deficient and tactics-deficient force develops enough combat power to overwhelm a smaller force that is richer in weaponry and tactics.

Synergistic effect of combined arms. Over the centuries new weapons and tactics have been added to armed forces in the attempt to impose new vulnerabilities on the opposition and to compensate for own-force vulnerabilities created by the opposition. Modern forces must cope with a great variety of weapons and tactics, some meant solely for attack, some for defense, some for deception, some as counters to enemy weapons and tactics, and some as counters to counters. Fundamental to military forces has always been the necessity to defend as well as attack. For this reason, it is not possible to maximize combat power by arming a force only with highly potent offense weapons. A case in point is overdependence by the Israelis on offense aircraft and armor at the start of the 1973 Yom Kippur war. A force could be designed for maximum potential by loading it with only the most powerful offense weapons and tactics, but it will fail in combat against a force armed with weapons and tactics which it cannot counter.

Throughout this process of proliferating weapons and tactics, the key to success has always been combination into complementary mutually supporting systems. This is the concept of combined arms. Weapons and units are used in supportive combinations such that the capabilities of each are maximized while the weaknesses are minimized. Each weapon and tactic has a role, and it is the combination of all working together that enhances the capability of the force as a whole. If any weapon or tactic is missing or deficient, force capability is weakened. In accordance with the conclusion stated above, the built-in mutual support results in a combined arms synergism that increases combat power.

In modern military forces, the combined arms concept is applied at all force levels. Forces are constituted as combined arms teams within larger combined arms teams within still larger teams from the smallest unit to theater forces. The principle of mutual support is applied universally: weapon systems protect other kinds of weapon systems and are protected in turn; there is support between like units and unlike units; support between ground, air and naval units; support between higher and lower echelons; support to the front and the rear; support laterally and vertically; and so on. To the degree that the principle of mutual support is followed, the combined arms synergism is felt throughout the aggregate force. Through synergy, the combat power of a force exceeds that of the separate elements of the force. James G. Miller, in *Living Systems,* arrives at a comparable conclusion regarding the parts of living organisms versus the whole.

As noted, however, a combined arms force has necessarily sacrificed offense combat potential that could exist were it not necessary to divert some capabilities to the defense. The existence of an enemy has forced the diversion of a fraction of combat energy away from the offense. The combined arms synergism thus starts from a reduced level of usable offense combat power. The synergy of combined arms should therefore be viewed not so much as an additive or multiplicative effect on combat potential and combat power, but rather as a partial restorative from the negative effect of vulnerability to the enemy. It is more accurately a quasi-synergism.

Properly used, the combined arms concept provides the commander with flexible means to cope with a multitude of combat tasks against a variety of opposing forces. It compensates for the deficiencies and vulnerabilities of any one force system by using the advantages of others.

Although the combined arms concept is of long historical standing, the modern version imposes great complexity on force design. Moreover, with expanding variety of weapons and tactics has come greater specialization in weapons and units. At the highest echelons, for example, different engineer units are available for bridge building, airfield construction, port construction, mine laying, and other tasks. Yet within the fractal-like hierarchical structure of military forces, we can find equivalent (though rudimentary) engineering functions down to the lowest echelons, where individuals may perform in a simple manner what specialized battalions do with great complexity at the higher echelons.

The key to obtaining a high level of combat potential is finding the best balance in both offense and defense weapons and associated tactics and doctrine to deal with a variety of anticipated situations and possible enemies. Since combat situations vary widely, proper balance within the constraints of designed potential and available potential will depend on flexibility to adapt the

combined arms balance to each situation. There is no universal optimum for combined arms balance.

The concept of combined arms balance has innumerable parallels in nonmilitary activities. Balanced combinations of offense and defense capabilities are essential in sports, for example. Perhaps the best example of balance is the biology of animals, where the capability of the body functioning as a whole is obviously greater than the sum of the capabilities of body organs, which in turn is greater than the sum of the capabilities of cells. The biological reason also parallels that of combined arms: organs and cells are specialized to provide coordinated mutual support, with considerable ability to shift support as needs demand.

In aggregating combat power, we can summarize the discussion above in the following conclusions:

- Combat potential and combat power are aggregated in a nonlinear manner through the hierarchical and lateral combination of force elements into larger units.
- A balance of combined arms results in a synergistic effect on combat power that is felt at all echelons. The cause of the synergistic effect is mutual reinforcement and support and its extent depends on the degree of reinforcement and support.
- Combined arms balance is essential to military forces. The proper balance depends on the particular combat situation. Flexibility in force design facilitates achieving the proper balance in a variety of situations.
- The combat power of a force cannot be maximized by using only systems that are by themselves powerful at the sacrifice of balance in complementary offense and defense systems.

7.4.5 Force Integrity and Cohesion in Combat

It has long been recognized that a combat unit needs coordinated, integrated teamwork to develop a high order of combat power. It is also recognized that even a moderate loosening of force integrity can lead to a large loss of effectiveness. The term *cohesion* has recently been used to describe the binding effect that holds a unit together despite the stresses of combat. Force integrity and cohesion as used herein are essentially synonymous except that force integrity can apply to forces of any size, while cohesion is a characteristic primarily of smaller units and is seen only vestigially in large units.

Unit cohesion is a key ingredient in achieving the synergistic, mutually-supporting effects of balanced combined arms. Cohesion holds force elements together. It acts as a binding strength, cementing units and individuals. The opposite of cohesion can be called *disjunction*, which acts to loosen connectivity within a unit, encouraging a tendency to come apart and lose force integrity. The terms are defined as follows:

Cohesion is *the condition of a combat unit whereby its elements are united in a common purpose and goal that is understood by all and its elements are in place, functionally connected, and operative.* This means that the unit is functioning as a unified system with connecting linkages not only available, but with their proper functioning understood and effectively carried out, a consequence not only of force design but of training and indoctrination. In other words, the unit is functioning cooperatively as the team it is intended to be—it cleaves together as a unitary whole. From the definition, it can be seen that cohesion signifies unity both structurally and as to purpose.

Disjunction is *the condition of a unit whereby it has in some degree lost unity of purpose or goal, force elements, functional connectivity, or any combination of these. It is the opposite of cohesion.* Disjunction involves the loss of any—or all—of the characteristics essential to cohesion. A unit can incur disjunction because of, for example, a loss of unity of purpose without any loss of its elements or linkages. Conversely, a unit may retain commonality of purpose but suffer disjunction through loss of force elements.

Before combat, a unit may be subjected to disjunction for reasons not connected with combat, but we are here concerned only with disjunction in combat.

Cohesion and disjunction are attributes of units, not of individuals. The term unit here refers in a generic sense to all manner of military organizations from small teams and crews to more formally organized larger units. Through lateral and hierarchical linkages, cohesion in a unit can induce cohesion in other units. In like fashion, unit disjunction can spread disjunctive effects to other units. Cohesion does not fully exhibit the property of aggregation, however, because its effects become dissipated as unit size becomes larger. It is a significant characteristic of smaller size units only.

Determinants of cohesion. One ingredient for the existence of cohesion can be designated a structural determinant, since it requires that a unit have the essential elements of its structure intact, properly linked together, and operative, with proper functioning understood by unit personnel and with the common purpose comprehended. This determinant entails force structure, matching doctrine and training, readiness, and mission understanding. It works from the top down, imposing unity of direction and organization from higher echelons.

The other ingredient can be designated a behavioral determinant, since it concerns how individuals and units behave in combat in response to the mission and the common purpose. The behavioral component of cohesion works principally through person-to-person bonding in small units. Bonding develops laterally within crews, teams, sections, company-size units, and ship's companies; and it develops vertically between commanders and those under them with whom they deal personally. The bonding results in cohesion. Although some degree of person-to-person bonding may occur in larger units and between a high echelon charismatic leader and his forces, cohesion is seen mainly in groups where face-to-face contact is frequent. This is why cohesion does not aggregate as force size becomes larger. The effect on combat power of the behavioral aspect of cohesion (and disjunction) occurs primarily in the lower echelons of forces, in contrast to the top-down working of the structural aspect of cohesion.

There are many causes that induce behavioral cohesion. Some are external to the unit, but most evolve from the close intimacy of personal contact within a unit, especially contact under the shared danger of active combat. Included are mutual hardship, dependence upon those close by for safety, peer influence, personal pride, affection received and given to buddies, the necessity to shoulder one's load in the face of a life-threatening situation, and similar influences. These influences predominate in units at lower echelons, particularly those exposed to enemy actions. The stress of combat heightens the bonding, so long as there is perception that all remains in order. Causes external to the unit include commonalities of many kinds: traditional military behavior, mutually shared values, cultural and ethnic homogeneity, religious beliefs, national aspirations, language. Additional external influences lie in common awareness of and commitment to the broad war aims set by the highest authorities. Facing personal danger, the aims of individuals in combat can differ greatly from those of higher echelons, but ingrained values go a long way toward keeping small-unit behavior congruent with higher level wishes. Even more important is the role of all those in the command chain, who act as the agents of higher authority in conforming unit behavior to overall purpose and values.

All military units enter combat with some degree of cohesion and all will be subjected in some degree to disjunctive influences as combat proceeds. Disjunction occurs when a unit has suffered structural damage or degeneration of behavioral unity.

Structural disjunction. The great variety of combat capabilities, counter-capabilities, and counter-counter-capabilities that technology has brought to warfare necessitates complicated combined arms structures and doctrines, and with them ever more complex mutual support linkages. The problem of complexity is magnified by increased dispersion of forces in combat, which, despite increased

communication capabilities, magnifies the difficulty of maintaining personal linkages and bonding.

Whenever there is loss, suppression, or malperformance of elements of the structure, there is concurrent loss, suppression or malperformance of the support links from those elements to other elements. Structural disjunction compounds loss of combat power through simultaneous damage to force elements *and* to support linkages. It follows that the more complex the combined arms design, the more susceptible it is to structural disjunction. Forces are designed with built-in redundancies and are cross-trained to mitigate this susceptibility, but the basic problem remains. The compounding effect of structural disjunction leads to the following conclusion:

- The loss of combat power in a unit subjected to structural disjunction is compounded because of the loss both of elements of the unit and the linkages from those elements to other elements.

The compounding negative effect can be illustrated by an example in which a unit is composed of five elements, each of which contributes an equal share to unit combat power and each of which depends on every other element to be fully effective. The five-element unit with four support linkages for each element is shown in Figure 17a. Now suppose there is a loss in combat of one of the elements, as shown in Figure 17b. Since loss of combat power results from the loss of support linkages as well as from the loss of the element, the total loss of power is the compounded result of the loss of one-fifth of the elements and two-fifths of the linkages.

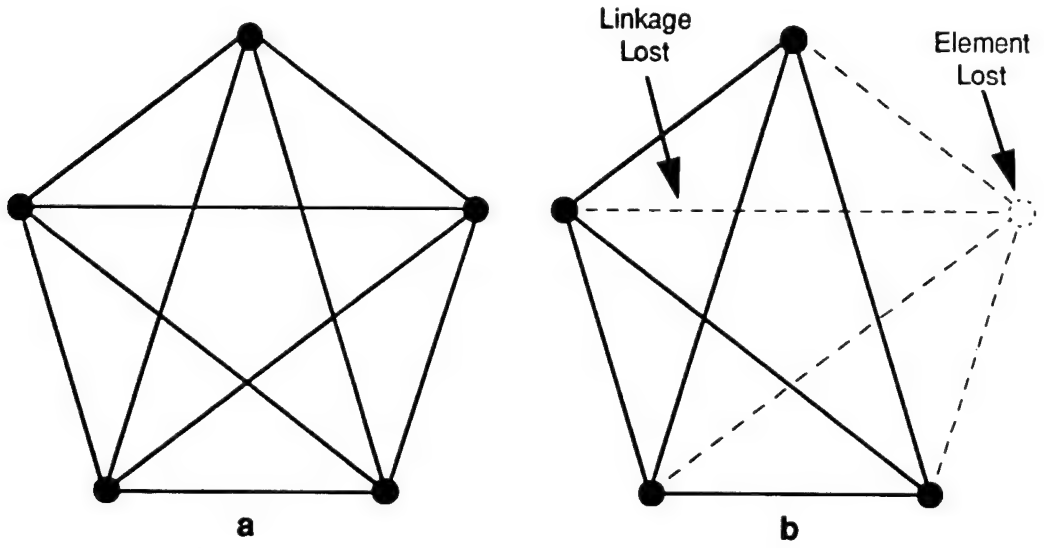


Figure 17. The Compounding of Losses from Structural Disjunction

The question of how much structural disjunction a unit can absorb and remain militarily effective has been given considerable study. The question becomes something like a sorites paradox: does the loss of one man make a unit no longer effective and thus cause it to break in battle? Two men? Twenty men? Eighty men? And so on until at some critical point the unit is judged to pass from functional to nonfunctional, that is from a unit to a non-unit. The usual parameter examined has been casualty losses in battle, and the break point has often been expressed as a percentage of casualties sustained. Sometimes materiel losses and other complexities, such as loss of leaders, have also been considered. If structural integrity were the only factor affecting unit capability, the existence of definable unit break points could well be a fundamental aspect of a theory of combat. But behavioral cohesion (and, in the more general case, behavioral integrity) is an important factor in unit effectiveness, and so a break point derived solely from historical casualty and materiel losses can only be an average that has built-in (but masked) behavioral factors. We are left with the answer to the sorites paradox: the unit in which Beau Geste (in the well-known story by Percival Wren) was the sole survivor remained functioning, while units on other battlefields fled after only a small fraction had become casualties. As the samurai Miyamoto Musashi stated in *The Book of Five Rings*, "The way of the warrior is resolute acceptance of death," so that a unit composed of warriors may not break until the last man has died.

Behavioral disjunction. Explanation of behavioral disjunction is more elusive. While structural cohesion and disjunction can be envisioned as working in a more or less mechanistic way, behavioral cohesion and disjunction work in psychological ways. They can result from top-down influences or from person-to-person influences at the lowest combat echelons.

Groups in combat carry out (to greater or lesser degree) directed group-oriented activity rather than random individual-oriented activity. With proper leadership, the group-oriented activity is polarized and vectored (to greater or lesser degree) by the combat mission, which in turn is polarized and vectored by the broader purposes of the campaign and the entire war. This is instilled top-down. Like polarized atoms in a magnetic field, individuals are oriented toward one consistent, unified goal, which contributes to cohesion. When polarization is widespread, the cohesive effect is widespread and units perform their group-oriented activities as intended by higher authority. But when polarizing is weak, vacillating, misconstrued, or implausible, cohesion is weak and misoriented. Disjunction can result whenever the polarizing signals from above are faulty, and fault can be injected at any command level. When it happens at a high level, the disjunction seen at the lower echelons tends to spread widely, although the effects can be ameliorated by good leadership at lower command levels.

Disjunction at the individual level occurs when the personal motivations of individuals begin to override the common goal of the combat mission, and by extension, of the broader war effort. Here the command structure again is critical as the conduit for goals and values. Since behavioral cohesion stems from person-to-person relationships, there tends to be an *infectious reinforcement* of either the positive effects of cohesion or the negative effects of disjunction. There is therefore a compounding of the positive or the negative effects upon combat power. The compounded infectious reinforcement is especially pronounced in regard to morale and fighting spirit. New personnel arriving in a unit characterized by high morale and belief in the mission will be infected with the unit's favorable attitude. In the other direction, loss of confidence in the value of pursuing the mission or in a leader can spread infectiously like panic in a crowd. Some factors contributing to cohesion are not readily subject to disjunctive infection, such as ingrained cultural traits and longheld traditions, and these tend to act as a brake on the more transient infectious factors.

Importance of cohesion. Cohesion enhances the aggregation of combat power, while disjunction degrades it, and does so in a compounded manner. Historical examples support the conclusion that the behavioral component of cohesion is more significant than the structural component. There are many instances where a unit in combat with strong structural cohesion was unable—because of behavioral deficiencies—to bring more than a limited level of combat power to bear. In contrast, there are many instances where a unit has suffered extreme structural disjunction, yet has maintained a high level of combat power because (it would seem) the unit retained behavioral cohesion. There are also instances where a force that suffered behavioral disjunction was rallied by forceful leadership. On the other hand, there appears to be few cases where a demoralized unit was restored during combat solely by reconstituting its structural elements.

The following conclusions summarize the role of cohesion in aggregating combat power:

- Cohesion and disjunction have a structural component and a behavioral component. With both components, effective linkages among force elements are critical to cohesion.
- The behavioral component tends to dominate over that of the structural component.
- Cohesion acts in a strong positive way to enhance the combat power of a force.

- Disjunction has a compounded negative effect on combat power which can lead to abrupt, cascading loss of effectiveness. The effect can occur with regard to either the structural or the behavioral component.

7.4.6 Human Behavior in Combat

The discussion of force cohesion and integrity highlights one critical aspect of human behavior in combat. The following addresses other aspects that affect the dynamics of combat.

Variability and predictability of behavior in combat. Axiom 6 states that uncertainty is inherent in combat. One of the most pervasive sources of uncertainty is how individuals and groups will act under the stress of combat. Behavioral variability affects all forms of human interaction. Yet, granting behavioral variance in general, there is, paradoxically, considerable predictability of human behavior in combat, both as to individuals and more so as to groups. Part of this predictability can be ascribed to innate similarities among humans and part to similarity in cultural influences. Additionally, predictability can be attributed to similarities in training, disciplining, and indoctrinating combatants, and the greater the uniformity in these pre-combat activities, the greater the predictability. Moreover, during combat predictability is enhanced by the cognitive inputs that affect all in common, such as the mission, orders, and other information disseminated to all.

The causes of human variability in combat obviously include genetic and physical differences, along with educational and psychological differences arising from cultural and social environments.

There is, however, one paramount distinction that influences individuals in combat differently from individuals acting in most other human endeavors: it is the realization of imminent personal danger. Fear is one dominant result, yet even in combat many factors tend to override what in other human activities often becomes a paralyzing effect. The bonds formed with others in the unit are an important factor in overcoming fear, as are command and peer influences and belief in the purposes of the war. Nevertheless, despite these conforming influences, in combat one human's response to fear can differ greatly from another's.

Because of the multiplicity of top-down unifying effects, variability between groups in combat is less than variability between individuals, and hence group behavior is more predictable than individual behavior. In part this is because the individual genetic, physical, and psychosocial differences are averaged out in groups. In addition, variability appears to be inversely related to span of control: a single soldier controls himself (a unit of one) and may act with great heroism

or may fail utterly. A platoon commander, on the other hand, controls a number of individuals and acts to integrate them within the plans of higher echelons. As units become larger, behavioral variability between them appears to become less. The averaging out of individual behavior becomes more pronounced and a sort of "law of large numbers" dominates. As units become larger, they progress to more predictable states.

We are led to the following conclusions:

- As unit size becomes larger, unit behavioral variability in combat becomes less, and consequently predictability of unit behavior becomes greater, the reasons being the averaging out of behavioral differences and the greater integrating effect of higher level commanders.

- The more the commonality and coherence of a force's pre-combat training and indoctrination, the more predictable will be the behavior of the force in combat.

Self-regeneration of units in combat. A unit in combat is in a constant struggle to stay alive and functioning. It must continuously cope with degenerative factors arising from the enemy, the combat environment, and the wear and tear of combat activity. As with all biological entities, a combat unit continuously draws upon dynamic feedback to sustain itself and adjust to survive; it learns as it goes. It must contend with conflicting goals: to fulfill its assigned task and to stay alive. Military units exhibit the same strong survival instinct of all living organisms, but they do so under the paradoxical circumstance of putting themselves at mortal risk.

Units in combat appear to exhibit an unusually strong ability to recoup from severe stress and regenerate themselves. This may arise in part from the perception that the unit is in mortal danger if it fails to regenerate and continue fighting. In addition, cohesiveness, to the extent it is present, clearly aids regeneration. Peer influence and altruistic dedication to the mission undoubtedly contribute, and also the anathema of being branded a coward. Yet, considering that a beleaguered unit usually has the option of surrendering and thereby precluding the need to regenerate and continue fighting, there appears to be an extraordinary innate capacity to choose otherwise and reconstitute functions essential to remaining viable, despite the danger. A leader steps up to replace the commander who has been killed, new linkages are jury-rigged to replace linkages destroyed, and the unit continues with ad hoc capability. The increase in entropy in a combat unit (in the form of chaotic, disorganized, disordered conditions) is opposed by the tendency within the unit to self-organize, reconstitute itself, and reestablish internal order. Self-regeneration of units in combat appears to be a strongly ingrained characteristic.

Recent work on complexity theory advances the thesis that self-organization of a complex adaptive system occurs at the boundary between well-ordered and chaotic behavior. Too much order stultifies growth and self-organization; too little results in instability and anarchy. Complexity theory offers some hope for a quantitative explanation of why effective fighting forces are neither too rigidly controlled nor too undisciplined. An example of self-organizing in military forces was the latitude given by Admiral Nelson to his captains at Trafalgar. By freeing his captains from the rigid strictures of contemporary doctrine, Nelson allowed them the initiative to self-organize under the stress and chaos of battle, that is, to fight cooperatively in mutual support with a minimum of direction from the top. A unit in combat is a learning machine with a strong incentive for fast learning.

As with cohesion, it is the behavioral characteristics of a combat unit more than the structural that will govern its conduct in battle. Combat is inherently about the dynamic behavior of people as individuals and as groups working with machines in a complex, interlocking system under great stress and for high stakes. It is the norm that stable situations will become chaotic, and it is innate in combat systems that—working at the boundary between order and disorder—they will continuously strive to regenerate themselves.

The property of self-regeneration and self-organizing can be summarized in the following conclusion:

- A cohesive unit in combat acts continuously to oppose actions causing its disorganization and debilitation by applying self-organizing, regenerative energy to reconstitute its combat capability.

7.4.7 Aggregating Combat Power

Once activated from potential, combat power is aggregated at the macro level and continually distributed, redistributed and vectored to accomplish the mission. Aggregated and distributed combat power are realities, as any commander knows, yet while conceptually obvious, the present state of knowledge offers no way of mathematically combining elemental combat power into larger agglomerations. Of the many attempts at quantitative summing thus far developed, most use firepower as the factor to be aggregated, ignoring such factors as advantages in leadership, information, maneuver, and morale that contribute importantly to combat power. Even those attempts that aggregate firepower usually focus only on the destructive effects to the neglect of other significant effects, such as suppression and demoralization.

Despite the lack of an accepted quantitative tool for dealing with aggregation of combat power, certain principles offer partial underpinning for a theoretical

approach. We have touched on combat friction, combined arms synergy, force integrity and cohesion, and human behavior. These and other factors affect how combat power is aggregated.

Although there is no mathematical model for aggregating combat power, we know from observation that aggregation does occur. The next chapter addresses the dynamics of applying combat power, in both elemental and aggregated forms, to accomplish the mission.

Chapter 8

DYNAMICS: APPLICATION OF COMBAT POWER

8.1 GENERAL

Once activated from combat potential, combat power is applied with two complementary aims to accomplish the mission. One is application to own-force elements to move them to fulfill the mission. This is accomplished through the internally directed processes. The other is application against the enemy to remove his opposition, which is accomplished through externally directed processes. In this chapter we examine the dynamics of applying combat power to these complementary ends.

8.2 COMBAT PROCESSES

8.2.1 The Role of Combat Functions and Processes

8.2.1.1 Primary combat processes. The structure of combat incorporates a set of primary combat processes which, taken together, are defined as encompassing all activity of combat. To reiterate, a **primary combat process** is combat activity of any kind that produces a common generic result. It is through the processes that combat power produces results aimed at achieving a mission. The results are those that actually occur, not those intended to occur by one side or the other. The primary processes were judiciously selected as suitable for describing combat; there is not a theoretical basis for choosing a particular set.

Any single action will normally produce more than one category of result and therefore involve more than one primary combat process. Here, however, we intend that each process be mutually exclusive of all other processes so that there is no commingling among them nor any gradation from one process to another. All destruction results, for example (and hence all destruction processes), are thus distinct and separate from all suppression results, all disruption results, all communication results, and so on, and consequently from all those processes. As an illustration, well-delivered air bombardment will normally result in some destruction, some suppression, some disruption, and often some degree of demoralization. By making each of these result categories distinct, we can, in principle, tabulate each category separately, although an observer would see

them mingled. Considering the processes to be mutually exclusive enables us to provide a more orderly description of what occurs in combat.

Although internally directed processes are just as important as externally directed ones, it is only through external processes that the enemy can be directly affected. The internal processes provide the enabling basis for external processes, in addition to providing their own essential contributions to mission completion.

In his book, *Living Systems*, James G. Miller describes nineteen basic processes as common to all living systems from cells to supranational entities (such as the United Nations and the European Community). Although he uses a different nomenclature, all of his nineteen processes can be related to one or more of the thirteen primary combat processes. For combat (involving, with the two opposing sides, a double subset of Miller's living systems), the thirteen processes are adequate to encompass all actions.

A single element taking an action against a single element will produce one or more results that fall under one or more of the primary combat processes. More often, an action will impact more than one object element and produce multiple results among each of the object elements. In the larger view, the elemental activities contributing to each process are aggregated to produce aggregated results under that process. At both the individual and the overall levels, all or most processes of combat will be in play by each side at any instant of time.

Combat results intended will always be favorable but actual results, and hence processes, can often, for many reasons, be unfavorable. The externally directed processes will generally be favorable (though only for the moment, because subsequent situations may render an initial gain disadvantageous in the longer run). Internal processes that work through cognitive elements—motivation, command-control, communication, and information acquisition—are especially susceptible to producing unintended adverse results.

8.2.1.2 The costs of processes. Every process has costs. These can be the obvious costs of expending resources—fuel consumption, ammunition expenditure, materiel wear and tear, human fatigue—but they can also be more subtle, such as the information given to the enemy by virtue of process execution, the time needed to execute the process, and friction losses incurred. These are costs borne by the party initiating the process. In addition, there are, of course, own-force costs in losses of men, materiel, and time attributable to the external processes carried out by the enemy. The efficiency of any process might be determined by weighing the costs against the results achieved; however, the mixing of process results and the indeterminate nature of costs would render any such calculation merely an abstract judgment.

8.2.1.3 Primary combat functions. Distinct from the primary combat processes are the primary combat functions. Like combat processes, the set of primary combat functions (listed in Chapter 6) is arbitrarily defined to be all-inclusive: every action undertaken in combat will, by definition, fall under one or another of these primary functions. Combat processes create the actual results achieved in the two-sided give and take of combat, whereas functions are the actions taken by each side to achieve intended results.

To illustrate, a commander will use the Army functions of maneuver and fire (along with other combat functions) with the intention of achieving results to further his mission. His opponent will do likewise. The fire and maneuver functions undertaken by each side will combine to create results that become the new actual situation. The new situation will certainly not be what both commanders intended, and usually will not be exactly what either intended. Regardless, both sides share the new situation, and depending on their perception of the situation, will initiate further actions. With both sides separately performing their functions, each side will have been carrying out processes that produce destruction, suppression, demoralization, protection, movement, communication, and so on, the actual results from the processes differing in some degree from what each side had sought. The combat environment will also have an effect on the shared results.

Thus processes concern actual results while functions concern intended results. Secondly, processes are output oriented in that they relate to effects, while functions are input oriented in that they relate to causes. Finally, processes concern the actions taken by all three parties to combat while functions are actions undertaken by each opponent separately. Combat functions are applied as energy vectored to fulfill the mission; combat processes are the consequences of the combined energy applied by both sides, as further modified by the environment.

A discussion of how the various combat functions are utilized and combined for best effect is not called for here. The voluminous literature on doctrine, tactics, techniques, and materiel is a far better source for describing how to wage combat. This theory of combat is in no sense a "how to" book.

8.2.2 Descriptions of the Primary Processes

To understand how combat processes work in the dynamics of combat, it is first necessary to explain each process and how it contributes to combat power, keeping in mind the differences between processes and functions and that each process is defined to be separate and distinct from all others.

Table 6 repeats the list of primary combat processes discussed earlier.

Table 6. Primary Combat Processes

Externally Directed Processes (which impact only enemy forces)	**Internally Directed Processes** (which impact only friendly forces)
Demoralization	Command-Control
Destruction	Motivation
Suppression	Information Acquisition
Neutralization	Communication
Disruption	Movement
Deception	Protection
	Sustainment

8.2.2.1 Externally directed processes

Demoralization process. The process of demoralization leads to breaking or reducing the will of the enemy force to continue its opposition. It operates solely on cognitive, not physical elements. The results range from doubt by individuals about continuing the fight to abject loss of will within the entire force. The most singular impact occurs when the commander of the enemy force is demoralized, but demoralization can occur from the bottom up even though the commander and his principal subordinates have retained a strong will to fight. To some degree, the process affects many combatants in every combat situation. When the process affects the command structure or becomes widespread among the rank and file, combat power can be catastrophically reduced.

With loss of will, the purpose and values of waging combat tend to be discarded in favor of the primal impulse to survive, hopelessness, and desire for psychological palliation. The vectoring effect of mission is diminished and in the extreme, no longer acts to focus combat activity. A force may disengage from combat for reasons other than demoralization, such as excessive fatigue or the need to preserve the force for a subsequent mission, but when the cause is loss of will, the demoralization process is at work. If demoralization has not progressed too far, the effects can be arrested and even reversed by forceful leadership.

The principal instruments for carrying out the process are fire and maneuver. Surprise, whether by fire or maneuver, can be an especially powerful demoralizer. The shock effect from a sudden, forceful penetration, an envelopment, or massive firepower, while often of short duration, leads not only to severe disruption but often to catastrophic demoralization. But demoralization can also result through gradual attrition of will from extended fighting and losses. Other combat functions besides fire and maneuver also contribute to the process, notably psychological and deception operations.

Destruction process. The destruction process works on all physical elements, both animate and inanimate, but not on intangible cognitive elements. The process also includes disablement and damage (partial destruction), even though subsequent repairs may be made during the course of combat. Similarly, wounding of personnel is included. The cumulative effect of the destruction process over time is attrition.

In modern combat, destruction is carried out almost entirely through the function of fire. Firepower of every kind is included, from small arms to bombs to chemical and nuclear weapons. Knives, bayonets, hand grenades, mines, incendiary materials, and many other weapons and devices are also used in the destruction process. At times, the combat environment may be the cause of destruction, as when ships are lost in a storm or tanks in a river crossing.

The destruction process contributes to combat power by physically reducing enemy elements—human or material—thereby directly decreasing the enemy's available means, and hence his ability to apply combat power. The destruction process is the most clearly discernible and measurable of all processes, so much so that it is often the only process examined in analyzing combat. Sometimes a combat mission will be stated as "destroy the enemy," but this is rarely meant literally; the true intent is more often to nullify the enemy capacity to fight through a combination of destruction and demoralization that will lead to catastrophic loss of force integrity.

Suppression process. The suppression process operates only on cognitive elements (humans), unlike the destruction process, which operates only on physical elements (both human and material). The effect on cognitive elements from suppression differs from that of demoralization in that suppression does not involve a loss of will to fight. It is primarily the threat of death or injury, leading to fear, that is at work in suppression. Even in the absence of fear of bodily harm, suppression can occur out of concern for preserving the materiel of a unit. The result involved in the suppression process is the curtailment of enemy combat activity that follows from the perception by individuals of danger to them or to other persons or materiel. That is why the process affects only cognitive elements.

The curtailment of activity is transitory and encompasses a great variety of degradations of combat power: infantrymen may keep their heads down to avoid being hit, thereby firing less frequently or less effectively; artillery batteries may cease firing and relocate if enemy counterbattery fire becomes too intense or is expected; an aircraft crew may take evasive action to avoid air defense fires, thereby reducing its attack effectiveness; a ground unit may cease a maneuver and take cover if enemy aircraft appear; a radar may be turned off or operated intermittently to avoid detection and engagement by the enemy.

Yielding to suppression is a rational act. A fearless combatant might not be suppressed, but he could be killed as a consequence; a seasoned, trained combatant may temporarily be suppressed but live to fight on.

Whereas the destruction process leads to physical damage and loss of elements, suppression causes neither damage nor losses; instead, it diminishes the amount and efficiency of the actions of enemy elements and thus decreases the opponent's combat power. The degree of suppression is the degree by which combat activity is rendered less effective. Suppression is less discernible and measurable than destruction, but is more prevalent on the battlefield and probably has a greater cumulative effect in most combat situations.

Whenever the destruction process occurs, the suppression process will usually also occur: if an individual is killed, others observing this will take cover and be suppressed. The converse is not true—the suppression process never has the result of destroying or damaging. Another distinction is that suppression may occur from firepower or threat of firepower, while destruction necessitates the physical delivery of firepower (or some other physical action).

Neutralization process. The neutralization process contributes to combat power through negating or denying the enemy's capability to bring all or part of its combat power to bear. Whereas destruction and suppression act to diminish the combat power of portions of the enemy force, neutralization totally negates a significant fraction of the enemy force, or sometimes the entire force for a period of time. The process frequently depends on successful use of the maneuver function to isolate the neutralized force so that its power cannot be usefully applied. Other ways to carry out the neutralization process include:

- Deceiving the enemy so thoroughly that portions of its force cannot usefully be employed (an example from World War II is the German divisions held in the Calais area for several days after D-Day in Normandy).

- Denying information to the enemy to such an extent that in its blinded state major force elements cannot operate effectively (such as many Iraqi troops during the Desert Storm ground attack).

- Cowing the enemy into inaction because he perceives his forces to be at an insurmountable disadvantage.

In all these cases, manipulating information acquired by the enemy is a key aspect, and the processes of destruction, suppression, disruption, and deception may have preceded and contributed to neutralization. The neutralization process resembles demoralization, but differs in that the cause is something other than

loss of will. A force that retains the will to fight but cannot do so because it has been isolated is neutralized but not necessarily demoralized. Surrendering is sometimes a consequence of neutralization by isolation.

Disruption process. This process includes activities that interdict the flow of enemy materiel and manpower, and also activities that disturb and delay enemy processes of command-control, information acquisition, protection, and sustainment. Since disruption usually has a transitory effect, duration of delay, along with the magnitude of the force disrupted, is a measure of enemy combat power reduction. If a bridge or rail line in the combat area is destroyed, delaying enemy forces or supplies that could affect the combat, then the process of disruption has been carried out together with the process of destruction. If the bridge or rail line is not destroyed, but forces have been delayed by an act of sabotage involving misinformation about the supposed destruction, disruption would have occurred in conjunction with deception but not destruction.

Electronic warfare and other information warfare actions provide means to disrupt enemy control, communication, fire direction, and information gathering activities through interference, jamming, and usurpation of communication links and control systems. Electronic warfare also contributes to the internally directed processes of information acquisition and protection. The distinction is that the disruption process utilizes electronic and other information warfare actions offensively for severing and interrupting enemy activities, whereas internally directed processes use electronic warfare to protect and enable internal actions. The disruption process differs from that of deception in that it does not involve a result of deceiving. Clearly, however, deceptive information warfare actions frequently will entail both deception and disruption processes.

Deception process. The deception process reduces enemy combat power by misleading the enemy's information acquisition process, and through this conduit, his command and control functions. It operates entirely through cognitive entities, striking at the enemy's central directing system. Techniques include directed misinformation, excessive information, ambiguous information, imitative communication deception, manipulative communication deception, decoys, fake materiel, ruses, demonstrations, feints, and the like. Many of these techniques are classed as information warfare.

8.2.2.2 Internally directed processes

Motivation process. The motivation process is the converse of the demoralization process. It works solely through individual cognitive elements of the friendly force. Where demoralization has occurred, motivation is the restorative, and where demoralization has not yet occurred, motivation is the guard against its occurrence. Motivation instills a force with the will to fulfill its mission in the

face of deadly threat from the enemy. More than that, it instills will to overcome normal societal mores and inflict death, destruction and demoralization on the enemy. All internal and external processes support the process of motivation insofar as they are perceived as succeeding, that is, leading to favorable outcomes.

The degree of motivation (or conversely of demoralization) is a crucial attribute of every cognitive element—every individual. Just as there are no aggregated cognitive elements, motivation works only through individuals. The motivation effect on units occurs through commonality of the motivation effects on individuals. This point also applies to all other processes that operate on cognitive elements.

The primary means for motivating during combat is the command function, supported by the functions of control and communication. Motivation is a key responsibility of all in the command chain. This top-down influence is buttressed by the bottom-up peer bonding that leads to motivation through cohesion. Just as essential are the ingrained motivations that individuals carry into battle. These stem from political indoctrination, training and discipline, military traditions and customs, national history and culture, family and home, and the broader purposes and values attached to the war effort.

Command-control process. The command-control process, working entirely through cognitive elements, directly and strongly affects all combat activities and thus all processes. The process encompasses not only the crucial decision-making and directing that emanate from the command function, but also the forms of control that every human in combat exercises on his own, as well as the preprogramming that humans have entered into weapons systems. Guidance commands to a missile from a console operator are included, as are the built-in commands of a homing missile. The decisions a truck driver makes in going from point A to point B are included. The inclusiveness is such that no action occurs in combat without a prior command-control process except natural phenomena and acts of chance. The process involves the organizing and weighing of acquired information—own-force information, intelligence information, prior knowledge and experience—and the development from this of decisions, directives, orders, estimates, plans, and all other forms of control.

Information acquisition process. This process has three components: acquisition of information about enemy forces, own forces, and the combat environment. Primary acquisition means are the human senses and technical sensors (radar, laser, sonar, electronic intercepts, magnetic detectors, infrared detectors, seismic devices, and many other systems). Secondary acquisition means are verbal and written reports and data in many forms that are acquired after information has initially been communicated from senses and sensors. Acquisition also encom-

passes information and data gathered during combat from sources such as field manuals, standing operating procedures, and computer files. Information acquired prior to combat such as a precombat estimate of the situation or analysis of own-force strength, contributes to combat potential and is not involved in this combat process.

With regard to own forces, the process includes information acquired from higher echelons and adjacent or nearby forces in addition to that from elements within the force. Information acquired about the environment includes data on weather, road conditions, cross-country trafficability, rivers and harbors, urban areas, and the civil populace. Although the act of acquiring intelligence information is aimed at the enemy, its purpose is for use internally within the friendly force and therefore the process is classed as internally directed. Acquisition of intelligence will often result in a direct impact on the enemy, but that impact occurs through one or another of the externally directed processes. As an example, the principal process for a unit on a mission of reconnaissance by fire is the internal process of acquisition of information (about the enemy), but external processes of destruction, suppression, and possibly deception and disruption will usually accompany the acquisition process.

Once acquired and transmitted, intelligence information is weighed together with own-force information in decision-making by commanders. This mental working of acquired information is part of the command-control process, not the information acquisition process.

Communication process. The communication process is a transmission activity (moving information from one point to another), in contrast to the information acquisition process, which is solely a procuring and receiving activity. A staff officer who obtains information from any source (say a computer file or a map) is engaging in information acquisition. If then, having put this information into a memorandum (part of his command-control process), he transmits the memorandum to another staff officer, he is engaging in the communication process; and when the second officer receives the memorandum, he is engaging in the acquisition process. The communication process entails any and all means of transmitting information, from oral to written to telecommunications and even smoke signals, hand signals and body language.

One of the final steps of the command-control process is the mental formulation of an order or a plan of action. When a commander writes out the order or plan, this is still part of his cognition in the command-control process. When he hands the written order to someone else or states it orally, he is using the communication process—information is moving from him to others. The same would apply if he was transmitting a plan, his concerns, or merely his ruminations.

Movement process. The movement process pertains to physical movements of all kinds in three-dimensional space. An infantryman crawling toward an enemy bunker is as much involved in the movement process as is a convoy of ships at sea or a squadron of aircraft flying toward a target. Trucks hauling supplies to reserve units far behind the front line are included.

A combat maneuver is a special case of a function performed by using the movement process (and usually other processes as well). A maneuver is an action intended to influence the enemy through a crucial positional advantage. The maneuver is not itself the result intended. Thus maneuver is an important function, but not a process. The 1986 version of U.S. Army Field Manual 100-5, *Operations*, states:

> Maneuver is the movement of forces in relation to the enemy to secure or retain positional advantage. It is ... the means of concentrating forces at the critical point to achieve the surprise, psychological shock, physical momentum, and moral dominance which enable smaller forces to defeat larger ones. ... Tactical maneuver ... is the means of gaining and sustaining the initiative, exploiting success, preserving freedom of action, and reducing ... vulnerability ... .

A maneuver may put several processes to work: external processes of demoralization, neutralization, suppression, and deception; and internal processes of movement, protection, command-control, and motivation. Firepower, using a combination of the processes of destruction, suppression, and neutralization, can be employed as a form of maneuver by fire.

Protection process. This process encompasses a broad set of activities that have the common result of protecting the force from the enemy's external processes and from his internal process of intelligence information acquisition. The most direct protection activity is fortifying against enemy firepower. Sea, air and land forces all employ armor protection and use screening measures, camouflage, dispersion, cover, and concealment to avoid enemy firepower. Electronic jamming that denies enemy interception of friendly force communications is another protective measure (but jamming of the enemy's internal communications falls under the disruption process). Electronic and physical countermeasure activities of many kinds contribute to the process. A broad range of protective measures is available to deny information to the enemy and is of increasing importance because of the critical value of information in modern combat. Protective measures against adverse environmental factors, such as storms, flooding, extreme temperature conditions, and nuclear or chemical contamination are included.

Other processes indirectly help in protecting a force. Destruction, suppression, neutralization and the other externally directed processes protect own forces indirectly by diminishing enemy combat power. Because the protection process directly wards off enemy actions, its contribution is to prevent the decrease in combat power that otherwise would occur from the enemy actions.

Sustainment process. This process supports all other processes. It involves sustaining all fighting, support, information acquisition, and command-control elements. The process embraces the broadest interpretation of what is included in the terms "logistics" and "support." It includes both manpower and material forms of support, such as personnel replacement, materiel resupply, medical care, morale, food supply, hygiene, transportation, ammunition replenishment, repair, maintenance, equipment retrieval, and field engineering.

Sustainment pertains to all echelons and locations of activity. A front-line soldier hauling ammunition or refilling canteens for the squad is engaged in the sustainment process. When he completes his task and begins shooting, he is back to the destruction or suppression process. A truck driver delivering rations in the rear of the combat area is performing sustainment (as well as movement). A surgeon working in a mobile field hospital is sustaining. An engineer battalion improving a road is sustaining.

8.2.3 Aggregation of Processes

Processes enable combat dynamics to be examined in light of the actual results that occur in the amalgam of both sides using combat power, each seeking its own desired end. Using process in the sense of any and all sorts of activities that lead to a single generic set of like results enables the aggregation of elemental activities into a manageable set of result categories. Thus all sorts of separate actions that a force may take that cause destruction (and damage)—use of maneuver, firepower, electromagnetic operations, disruption operations, blockade, whatever—can be aggregated into destruction results at any instant of time or over a period of time. Similarly all the actions that lead to destruction in one sector of fighting can be aggregated at any instant or over a period of time into destruction results in that sector; or one can aggregate just the results of artillery destruction in the sector. Likewise, these same actions can be examined to aggregate suppression, neutralization, deception, or other process results. Processes also are amenable to disaggregation: the total results of destruction or suppression in a given sector over a given time interval can be broken down into the contributions from certain weapons or in certain subsectors. The same properties of aggregation and disaggregation apply to the internally directed processes (although it is difficult to envision how to aggregate motivation, command-control, and communication).

8.2.4 Relationships Among Combat Processes

External and internal processes serve the mission in different ways. There is no priority of one category over the other, nor of any one process over any other. All processes are used in concert with the aim of mission fulfillment.

Any single process represents a category of combat results. All categories of results occur simultaneously within the combat arena, but at any one time and in any one place, certain processes will dominate because of the particular combat activity that one side has initiated at that time and place and the counteractivity that the other side responds with. The consequences of the two sets of input activity are the processes with their associated results.

8.2.4.1 Process relationships. Each process bears a relationship to the other processes, and these relationships differ for each process. Figure 18 depicts, in simplified fashion, the general nature of the relationships. The description of the processes presented above provides additional insights. The figure should not be considered a flow chart of combat activity; it merely shows the principal ties of one process to another. There are additional cross ties not shown.

The upper part of Figure 18 shows the processes of the Blue force; the lower part shows those of the Red force. Each side is, of course, drawing from the same assortment of processes (as well as the same functions) to further its ends. As noted in Chapter 5, there is structural symmetry in the processes (and functions) between opposing forces, but obviously there is never symmetry in the dynamic application of functions and consequent processes by the two sides. Structural symmetry does not mean symmetry of combat capability. The process relationships shown in Figure 18 remain identical through all hierarchical echelons from individuals to complete forces.

Information acquisition from a higher echelon outside the combat arena serves as a starting point in the figure. The information acquisition process impacts other processes only through the command-control process. The first step in the command-control process is to translate acquired information into meaning as deduced by the recipient of the information. From this step, the command-control process proceeds through many cognitive activities internal to the person which lead to the process of communicating with individuals and units and to motivating others. The motivating and communicating processes in turn lead to the processes of moving, sustaining, protecting the force, and acquiring further information. In due course, they lead to the external processes of demoralizing, destroying, suppressing, neutralizing, disrupting, and deceiving enemy force elements, thereby degrading the state of the Red force. All Blue internal

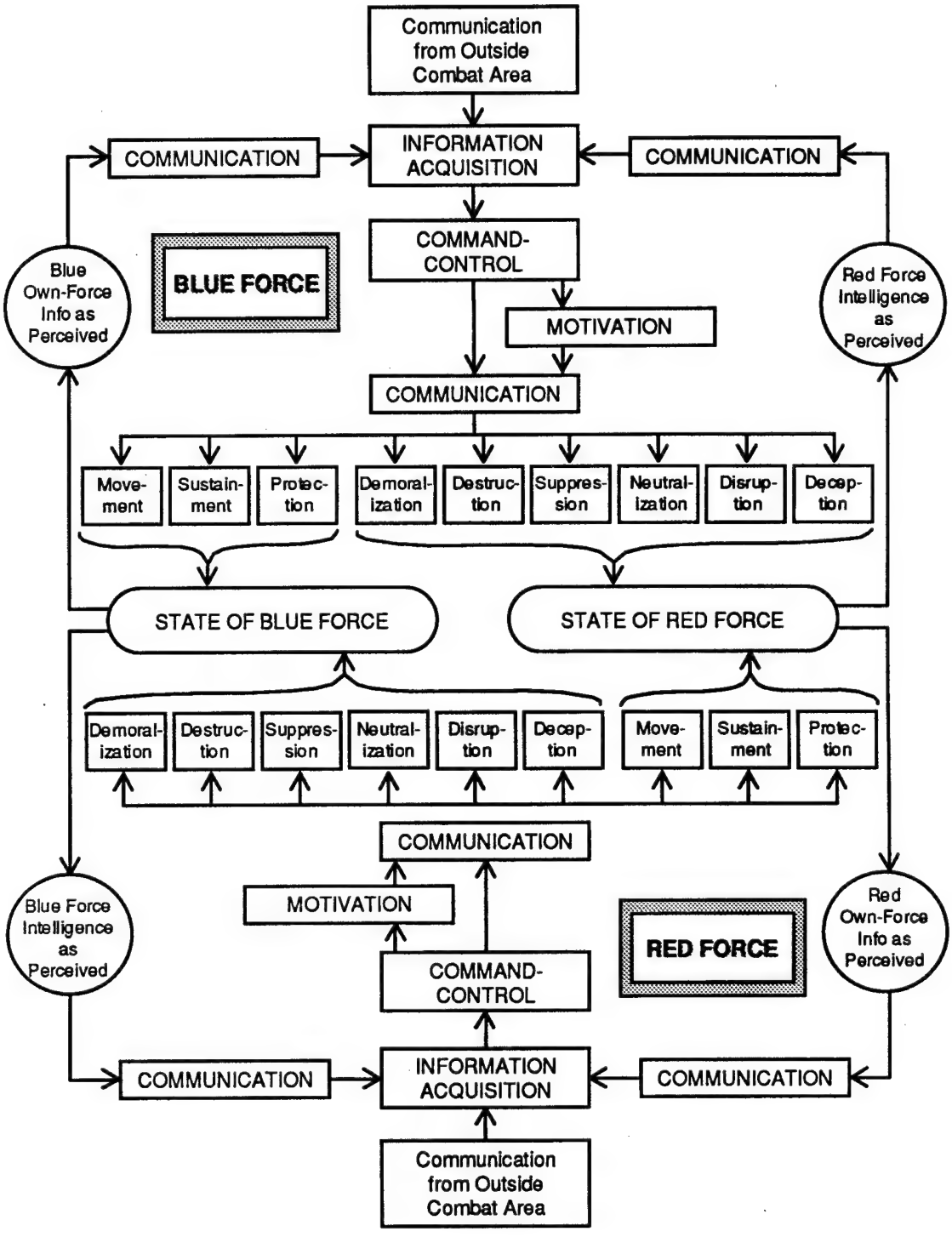


Figure 18. Combat Process Relationships

processes impact the Blue force, changing its state, while the Red force external processes are also impacting the Blue force, causing other changes in its state. Elements of the Blue force detect the changes in the Blue force state, and perceptions of these changes are communicated back into the loop once again through the information acquisition process. The same applies to Blue detection of changes in the Red force state and the feedback of perceptions of these changes.

The processes work in a continuous flow, but the flow need not cycle through all the relationships shown in Figure 18. A commander working the command-control process may interrupt his thinking to check a map, using the information acquisition process, then return to the command-control process. The external processes tend to occur in episodic peaks, whereas the cognitive-oriented internal processes are active almost continuously.

8.2.4.2 The cognitive processes. The process of command-control is ubiquitous and, together with motivation, is paramount in combat. Excepting chance events and actions caused solely by the combat environment, no combat activity of any kind, and therefore no combat process, occurs except as a result of an initiating command-control process. Furthermore, no activity (and hence no process) can support the mission effectively without the prior process of motivation. These points apply to everyone in combat—low ranking individuals as well as all in the chain of command. Command-control and motivation directly influence only friendly force elements. Neither a commander nor any other individual directly controls or motivates the enemy, but through these same processes, a commander and his force will indirectly seek to demoralize, destroy, suppress, neutralize, disrupt, and deceive the enemy. Facilitating the command-control process in its use of the external processes are all the other internally directed processes.

The command-control process, while paramount, nevertheless depends on information acquisition to make good decisions and on communicating to get the word to the troops. In addition, the motivation process works with the command-control process as a sort of a qualitative enhancer. These four internally directed processes—information acquisition, command-control, motivation, and communication—work principally through cognitive actions. They are the agents of the corresponding functions of command-control and information acquisition.

8.2.4.3 Other internal processes. The sustainment and movement processes contribute to all other internal processes. The protection process may either be enhanced or reduced as a consequence of movement, but the protection process does not conversely contribute to movement. Protection acts solely to mitigate the impact of the enemy's external processes and intelligence gathering.

8.2.4.4 External processes. With regard to the external processes, destruction will almost always have suppression and disruption associated with it, and sometimes neutralization, but suppression, disruption, and neutralization often occur without destruction. The deception process works through the opponent's information acquisition to reduce the efficacy of the enemy's command-control functions, whereas the demoralization process acts in a broader sense to infect the will of many or all human elements. Suppression impacts only human elements, while destruction, disruption, and neutralization affect both human and material elements.

It is common wisdom that for every combat action there is a counteraction. This is valid for combat processes as well, but the counter to any single process usually involves several processes. The countering of combat functions works in the same way: the counter to any single combat function will normally entail the exercise of more than one function by the opponent.

8.2.5 Summary of Combat Processes

By way of recapitulation, the following are key points regarding the role of combat processes in the theory of combat:

Combat processes are defined in terms of results actually achieved in the three-sided flux of combat. In this regard they differ from combat functions, which are oriented to results intended. Results achieved are the true new states of both sides and of the combat environment, as distinguished from the perceived states.

The set of primary combat processes is chosen to incorporate every kind of result that occurs in combat and is defined to be inclusive of all results that occur. Each process is mutually exclusive of all other processes. Although the list of processes could be extended ad infinitum, the set selected provides a convenient categorization that facilitates the description of combat.

Only externally directed processes impact the enemy directly and act to eliminate enemy opposition. Internally directed processes are essential to support external processes and to contribute to mission achievement; they impact only own-force elements, and in this way affect the enemy indirectly. Those internally directed processes that involve cognitive actions—command-control, motivation, information acquisition, and communication—can have either favorable or unfavorable effects on combat power.

No activity by either side, and therefore no process, takes place without the occurrence of a prior command-control process. Thus the command-control process initiates all other processes. It is, in turn, dependent on the information acquisition process.

Combat processes have the properties of aggregation and disaggregation.

8.3 UNCERTAINTY AND CHANCE

8.3.1 Defining Uncertainty and Chance

8.3.1.1 Uncertainty. Axiom 6 states that uncertainty is inherent in combat. We define **uncertainty** as *a state of doubt about the combat situation, including its outcome.* Uncertainty in combat is pervasive. It enters combat by its effect on the cognitive states of all combatants, and hangs like a fog affecting everyone, especially those in the chain of command. Commanders and their men have no choice but to learn to live with uncertainty, and chance. Commanders do their best to reduce uncertainty, yet only a foolish commander expects to eliminate it; and all commanders try to maximize uncertainty on the part of the enemy to obtain a relative informational advantage.

8.3.1.2 Chance. We define **chance event** as *an event that occurs without discernible human intention or cause.* With this definition we take a narrow view of what can pass as chance. An event that could have been anticipated and avoided is not a chance event, even though its occurrence was only a remote possibility. In the old maxim that starts "For want of a nail, the shoe was lost" and ends "for want of a battle, the kingdom was lost," the loss of the horseshoe is not strictly a chance event because with any message so critical to the kingdom, duplicate messages ought to have been sent by two riders. A sentry falling asleep, thereby allowing the enemy to take his unit by surprise, is not a chance event, nor is the death during battle of a commander with a known heart condition. An earthquake is a chance event but a predictable heavy snow storm is not. These examples put a fine point on what should be viewed as chance in combat. The wise commander anticipates and prepares for unusual events that others might class as chance, while an inexperienced commander will blame all sorts of surprises on chance or bad luck. Chance plays no favorites, and it can create opportunity as well as ill fortune.

Nevertheless, small non-chance events in combat can lead to large effects. The failure to detonate explosives to demolish the Remagen Bridge in World War II (not a chance event) expedited the Allied Rhine crossing. Chaos theoreticians found there are countless minuscule points in a chain of events where a small perturbation can magnify to ultimately produce very large changes. Combat is

likewise filled with many such seemingly small unforeseen happenings, each with the potential for causing drastic changes in the situation down the road. More recently, chaos theoreticians have discovered that they can sometimes manipulate the perturbations and stabilize the system back into predictability. Those who command in combat have likewise learned to react to and often control unforeseen happenings in order to minimize their effects and sometimes to channel them to favorable advantage.

8.3.2 Determinism and Predictability

Did the loss of a nail on the shoe of the horse carrying the rider unalterably determine that the battle would be lost? Clearly not, for any number of possible actions could have intervened to alter the chain of events. There is no evidence to indicate that combat is deterministic, no evidence that indicates the present state of a single element or the present aggregated state of an aggregated element absolutely determines any future state. An assertion that combat is deterministic would, by extension, seem to claim that the initial conditions at the outset of combat inevitably establish the outcome, and by further extension, that the universe is set on a sequence of predetermined events and outcomes. If combat were wholly deterministic, it should be totally predictable. But as chaos theory shows, nonlinear dynamic systems that seem to meet the characteristics of determinism are not deterministic because they can be utterly unpredictable. Combat, which involves two-sided, interactive, nonlinear dynamics, and which furthermore is not isolated from external influences, and further still, is more biological in character than physical, cannot be classed as predictable.

Yet, from a broad perspective, much of what can be observed of combat appears to be *a priori* deterministic for most practical purposes and much appears to be predictable within rough but useful ranges of accuracy. Just as the finite amount of encoded information contained in a fern spore predictably results in a nonrandom, fractal-like fern leaf, so the finite number of elements and actions in combat act in nonrandom fashion to produce (reasonably) predictable fractal-like patterns in combat. They do so because they involve the consistent encoded forms of military training, discipline, indoctrination, and traditions that control much of human behavior in combat. Also, because of the large numbers of combatants, weapons employed, and munitions and supplies expended, expected or average values from innumerable stochastic or quasi-stochastic events begin to override the details of individual events. CEPs (circular errors probable) make sense in large numbers, if not in the drop of a single bomb. Another factor contributing to seeming determinism and rough predictability is the intuition that good commanders bring to combat, which tends to lead to self-fulfilling outcomes; they prefer combat conditions where the outcome is likely. Competent commanders become expert in dealing with the fuzzy facts and

situations that abound in combat and in translating fuzzy information into non-fuzzy orders.

Having recognized the frequent appearance of predictability in the aggregate view (for most practical purposes), we must acknowledge that this pertains only where expectations seem strongly to favor a correct prediction. Commanders seek situations where they expect to succeed. They assess risks and avoid, when they can, situations where success is marginal or unlikely. Predictability is low in cases of small marginal advantage and can go off the scale where chance or an unforeseen event intervenes significantly.

In summary, we assert that combat is fundamentally nondeterministic and unpredictable, but that, for many reasons, much of combat can be viewed in the broad perspective as seemingly being determinable from preceding events and hence being predictable within tolerable limits of accuracy. In other words, there often can be a high order of probability as to outcomes. This view must not be treated too universally: we mean only that there is, in apparently clear cases, rough predictability of overall results, provided that significant unforeseen events do not occur. There is not predictability in detail and not predictability in general.

8.3.3 Effects of Uncertainty and Negative Information

Uncertainty. Pervasive uncertainty affects every combatant from start to finish. Combat proceeds on the basis of perceptions of reality rather than reality, and these perceptions are skewed by many factors: incomplete information, inaccurate and erroneous information, apprehension, fear, disinformation, deception, the biases and predilections of individuals (particularly those in the command chain), and other conditions afflicting cognitive elements. All of these factors result in what can be called the cognitive entropy of combat: the measure of uncertainty, confusion and disorder perceived by each combatant.

Let us postulate a situation that we know cannot exist: a situation in which, at a moment in time, every combatant has complete knowledge about everything in the combat arena—about every person, every material element, the location and every attribute of all these elements, and every action being taken at that moment. Uncertainty would still exist, for there are "uncertainty principles" that say you fundamentally cannot know, within certain limits, all dimensions of some things. The Heisenberg uncertainty principle of quantum mechanics says we cannot simultaneously know both the exact velocity and the exact position of an object. The linear time-invariant uncertainty principle of information theory says that there is a basic uncertainty in what we can know about both the frequencies and the time duration of a signal. However, these and other

uncertainty principles become significant only when we are concerned with measurements requiring great precision. Therefore, to put this point in perspective, in combat, scientific uncertainty principles become lost in the noise, even at the most elemental level. While the uncertainties exist, they are so overridden by the grossness of combat activities that they become inconsequential.

A more significant reason why complete knowledge would not eliminate uncertainty is that, given the nondeterministic character of combat, what happens next and what will happen later on cannot be known exactly. Even if every person on one side could know exactly what he will do the next moment, none of them knows what any person on the other side will do, nor even what the person standing next to him will do. Even if complete knowledge of the present down even to molecules or atoms were possible in combat, uncertainty would remain as to future states.

But to return to a realistic plane, uncertainty as to the present situation is seen everywhere. There is uncertainty as to many of the present-state attributes (location, morale, capability, posture, force integrity, and so on) of both the friendly force and the enemy force; uncertainty as to the validity of information; as to whether orders have been carried out; as to the combat environment; as to what losses have been sustained—in short, uncertainty as to much of the current state of forces on both sides and of the environment. The longer the train of sequential events since the last bit of information, the greater the uncertainty and the more the information is mistrusted.

Compounding the problem of uncertainty is what can be called negative information. It too is pervasive in combat. It includes information that does not result in uncertainty in the sense of doubt about the situation, but it can have an even greater influence. Negative information includes disinformation and deception intentionally planted by the enemy, as well as own-force misconceptions, misapprehensions, and other inadvertent own-force disinformation. Further, it includes ignorance, particularly by those in the command chain. A commander (or any combatant) may have no doubt in his mind about the situation, yet be completely ignorant of the true circumstance. He would be better off knowing nothing and realizing he knows nothing. The effect of negative information is to warp the perception of what otherwise should have been factual information.

8.3.4 Cognitive Entropy

The degree of uncertainty about the present combat situation can be thought of as a measure of the cognitive entropy of combat. We are not speaking here of

thermodynamic entropy, but entropy in the sense of information theory. Thermodynamic entropy could not apply because combat is not an isolated, closed system and it involves biological systems that are self-regenerating and self-controlling, and hence cognitive entropy can be reduced by factors both internal and external to the combat arena. The informational uncertainty involved in cognitive entropy pertains to more than just the physical situation, for it includes uncertainty as to the mission and orders and, on a more abstract plane, as to combat purpose and values. This conceptual sort of entropy is extremely hard to pin down. It might be called fuzzy entropy, since we are dealing with fuzzy sets of information. Although the actual situation is not fuzzy, what enters the minds of combatants is clouded by uncertainty.

Conceptually, we can define this fuzzy cognitive entropy as the ratio of what is not known about the combat situation to complete knowledge of the situation, the unknown relative to the knowable. In this sense, it is a measure of the confusion, disorder, and uncertainty experienced by combatants. Everyone in combat is at all times trying to minimize his own cognitive entropy and that of his fellows. At the outset of combat, the collective entropy (the sum lack of information by all combatants) of each side is usually low for friendly forces but may be high or low about enemy forces. As combat proceeds, entropy normally increases (the so-called fog of battle), but will wax and wane as correct information is acquired or fades and as it is correctly or falsely interpreted and understood. In the worst case, when individuals have lost all interest in the mission and know only what they can see with their own eyes, cognitive entropy is at a maximum. At the conclusion of combat, cognitive entropy in regard to friendly forces decreases and in regard to enemy forces generally increases.

From this discussion, two points seem to emerge. First, cognitive entropy has useful meaning only when considered separately for each side. The total entropy in the combat arena, being the ratio of what is not known by both sides to the complete combat situation, tells us little about the dynamics of combat, whereas the entropy experienced by each side separately clearly has a significant bearing on force capability. Second, cognitive entropy in combat probably exists only in the mind of each individual, just as there are no aggregated cognitive elements, only cognitive individuals. Nevertheless, cognitive entropy, as it affects each side, can be conceptually thought of as the combination (but not the arithmetic sum) of the cognitive entropies of all individuals of that side.

8.4 DISTRIBUTION AND VECTORING OF COMBAT POWER

8.4.1 Command-Control: Process and Functions

8.4.1.1 The gray world of command and control. Given the pervasiveness of uncertainty in combat, all who engage in command and control functions—which includes every active combatant—operate in a world where most available information is uncertain and ambiguous. Added to this is the occasional unforeseen event that ramifies to unexpected significance and the rare chance event that upsets plans. From this fuzzy world where facts are gray or missing, decisions must be made and communicated in clear, black and white terms. For those not in the command chain most decisions are made largely by rote in accordance with what the individual has been trained to do. Those in the command chain, however, face weighing choices that are often tortuously difficult, but when made, need to be communicated positively and decisively. As General Maxwell D. Taylor citing from the Bible said, "If the trumpet give an uncertain voice, who shall prepare himself for war?"

Thus command necessitates converting conditions of uncertainty into unambiguous orders and actions. This entails sorting through uncertainties and possibilities of chance and unforeseen events, and then filling in the unknowns based on experience and probabilities. From this cognitive exercise, the commander communicates his decision. The command function has the intent of making a right decision and enunciating it firmly and clearly. The command-control process leads to a decision that may be good or bad and that may be disseminated clearly and forcefully or not.

8.4.1.2 Experience and probability in command and control. Wise commanders, realizing they cannot know everything about the combat situation, do not delay action while seeking ever more information, but sense when they know enough to act. Commanders operate much like the brain, which, observing a developing pattern, interprets the partial pattern based on experience, and when sufficient pieces of the pattern have been received, anticipates the full picture, weighs options and decides. The commander will make a judgment about the probability of what the developing pattern represents and about the likelihood the pattern will not change. Included among the probabilities will be the commander's view of what his opponent will likely do based on knowledge of that opponent's past actions. Many other probabilities will be weighed and ranked to produce an overall probability. This calculus of partial patterns and weighted probabilities is at the heart of decision-making, not just in combat, but in all manner of human decisions. The commander finesses unpredictability in detail by working on probability in the larger picture. And successful

commanders convey decisions in terms that reflect neither improbability nor unpredictability.

Experience obviously is a paramount factor in command and control. Everyone in combat carries in his mind the accumulated residue of his experiences in life. But it is experience more directly related to military life and to combat that dominates command and control. Here the specific purpose-value system of combat overlies and must contend with the deeper purpose-value system of culture. Continuous information feedback to all combatants is weighed against these specific and broad purpose-value systems, leading to cyclic decision-making. All in the chain of command, and less directly all others, are guided by decision rules that derive from the behavioral incentives and penalties of higher military and governmental echelons.

8.4.1.3 The esprit component of command and control. Axiom 5 states that domination is the ultimate means of achieving an objective. It is certainly not the sole means, for only destruction will defeat a force that fights to the last. Domination is a defeat of the human spirit. In combat this means one force imposing its will on the other force, with the commanders on each side, aided by their subordinate commanders, being the principal imposers and principal recipients of domination. There are instances of a demoralized force becoming dominated by the opponent regardless of its commander's strong will to resist, and other instances where a force remained undominated even when its commander had been reduced to abject helplessness.

Domination works on the cognitive elements of the enemy. The means to achieve domination comprise all the external processes, with demoralization as the primary tool, and destruction and deception likely to weigh more heavily than the others. The shock effect of surprise magnifies the impact. Resistance to domination puts all the internal processes in play, but especially motivation and command-control. The esprit component of command and control has been expressed by Wayne Hughes in *Combat Science* in these words:

> Domination works on the mind and spirit. ... The winner instinct, not the killer instinct, is the attribute that explains the spiritual basis of combat success. Combat is the most intensely physical of all human activity, but after religion it is also the most intensely spiritual in its lasting effects. The health of one spreads to enhance all, and a sickness in one debilitates the others.

8.4.1.4 The episodic nature of combat. Combat rarely proceeds at a uniform pace, nor in a gradual build-up to a single climax followed by a winding down. There usually are peaks of heightened activity followed by periods of relative quiet. As the common saying has it, "war is moments of stark terror between

long periods of utter boredom." The episodic nature of combat is seen in all its aspects: there are times when information gathering is the primary focus, times when positioning forces is the main object, times when maneuvering is key, times when firepower is dominant, and times when recuperation is called for. The decision-making system, from commander down to private, all trying to cope with uncertainties and unknowns, requires time to ponder, and thus generates its decisions sporadically rather than continuously.

8.4.2 Distribution of Combat Power in Time and Space

Although combat power comprises innumerable quantum-like elemental contributions, it is not seen that way by commanders nor other combatants. To further his mission, a commander views combat power as being brought to bear by aggregations of forces and actions that he must control in time and space. Even though unity of effort and concentration of forces are watchwords of command, never in the real world would a commander treat combat power as if it were a single lump sum. Instead, he distributes and redistributes it by allocating forces and directing their actions here and there in a continually shifting pattern.

Once a commander has turned available combat potential into combat power, the two most crucial responsibilities for him and his subordinate commanders are (1) propitious distribution of combat power in time and space and (2) vectoring that combat power to achieve the mission. Commanders normally will also ensure sufficient residual potential to fight again, unless the force must be sacrificed for some higher goal. In carrying out these responsibilities, the commander and every combatant will be expending energy—usually prodigious amounts of it and often to the point of exhaustion.

Distribution of combat power takes place in the dimensions of space and time. Spatially, the vertical dimension extends from ocean depths to outer space and it may include subterranean space. The horizontal dimensions can extend anywhere within the combat area. At the micro level, combat power distribution is in finite granular bits, power being made up of the many separate individual processes occurring on the battlefield. On the macro scale, distribution has the appearance of bundles in time and space.

8.4.2.1 Spatial distribution. Figure 19 presents a fine-grain snapshot of Blue force combat activity within a small slice of the combat area during a short period of time. A complete picture would include Red force combat activity as well. The dots represent individual elements. The solid arrows represent physical actions taken by the elements, which impact other elements, either Blue or Red, and the dotted arrows represent cognitive actions. Thus each dot-arrow-

dot corresponds to one individual element-action-element activity with a consequent result. Most of these activities involve multiple impacts and multiple results. The small circular arrows indicate impact on the element itself (such as a change of state due to a movement or to ammunition expended).

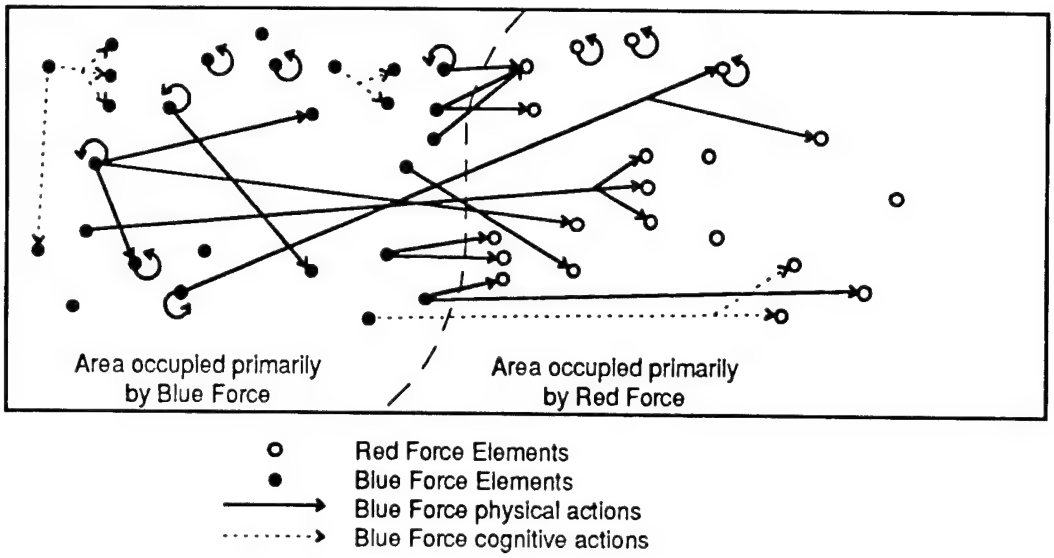


Figure 19. Fine-Grain Snapshot of Blue Force Combat Activity in a Slice of the Combat Area

Since combat power is defined in terms of results achieved (leading to changes of state), the point in space and the instant in time that a result occurs is the location where and time when an element of combat power is created. The word "point" should not be taken here to have the mathematical meaning of infinitely small, but rather to mean a finite yet very small volume; similarly, "instant" does not mean an infinitesimal segment of time, merely a very short segment. Hence in Figure 19 a micro bit of Blue force combat power created at each of the impacted dots (as noted above, Red force activity has not been displayed). Internally directed processes create supportive combat power only within space occupied by elements of that force, since by definition these processes only impact friendly force elements, while similarly, externally directed processes create aggressive combat power against the enemy only within space occupied by enemy elements.

At the individual level, every element that affects the combat situation, whether through physical action or through cognitive influence and whether affecting enemy or friendly force elements, contributes to combat power. The elemental bit of combat power is formed in the processes in which one or more agent elements impact an object element, including interaction with any enemy element that may impact the same object element. A maneuvering tank and its

crew that is firing at an enemy armored personnel carrier while receiving return fire is normally engaging in several external processes and could simultaneously be engaging in all internal processes except sustainment, all contributing to combat power, some against the enemy personnel carrier and some within the friendly force tank. Where the process result occurs is the where combat power is exerted.

The object elements, where elemental combat power is being created through changes of element attributes, can be any own-force elements (including the agent elements themselves), elements of the enemy force, and the combat environment. Furthermore, the object elements are not necessarily those intended to be the objects of an action, and often are objects against which the action was quite unintended. In instances of friendly fire casualties, for example, the objects are own-force elements fired on in error—an instance where combat power has a negative consequence. Civilian noncombatants and civilian infrastructure can become objects of collateral civil damage either intentionally or incidentally. In area fire or aerial carpet bombardment, the objects are not discretely targeted elements, but are any and all elements affected by the area fire or bombardment in addition to those for which damage was intended.

Each of the elemental combat power contributions is part of the overall distribution of combat power on the battlefield at that moment. In principle, for every spatial point in the combat arena, it would be possible to combine all the elemental power contributions at that one point at one instant. A mapping of all these elemental power combinations over the combat area would, for each adversary, represent a picture of the total spatial distribution for that side at that instant.

Figure 20 illustrates such a mapping over a portion of the combat area. The figure represents overall distribution of Blue force combat power at one instant of time. As a simplification, the figure does not include Red force combat power. A complete portrayal would show power of the two sides superimposed but distinct from each other. For each side the combat power at every point results from the interactive combination of both sides' activities that impact elements at that point at that instant, plus any effect that the combat environment has. Although a demarcation line is shown between the areas occupied by Blue and Red forces, there often is no firm separation of forces. Some Blue forces can be operating (and creating combat power) within the area where Red forces predominate.

Since external processes will at times create more of the total combat power than will internal processes, Figure 20 shows a greater portion of Blue's combat power within the Red force area. This will not always be the case. During

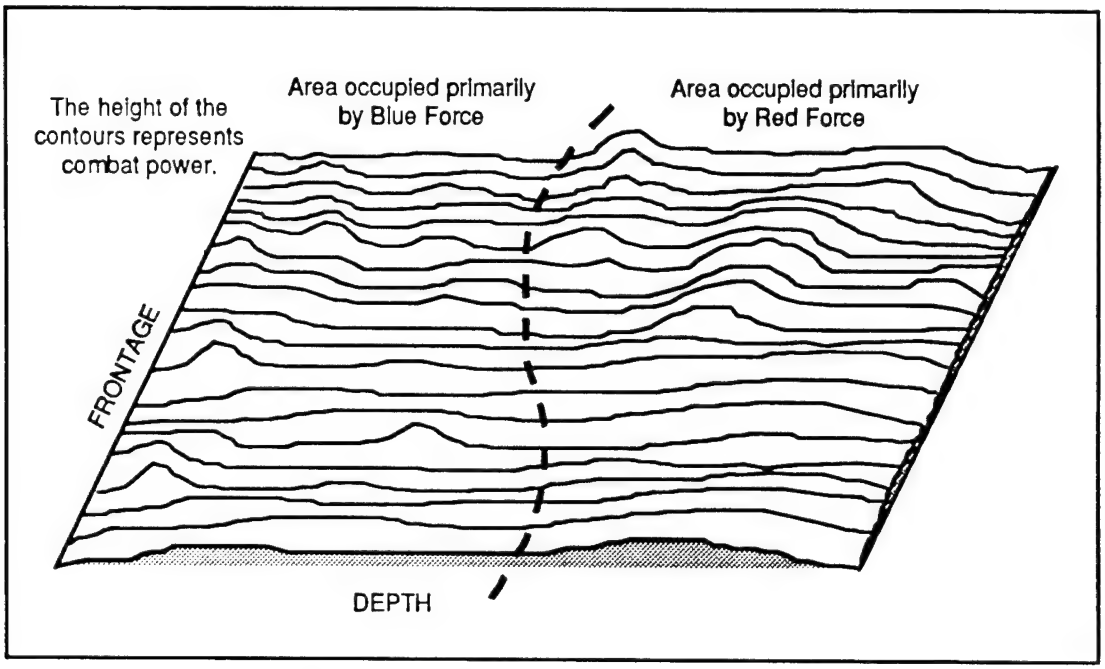


Figure 20. Spatial Distribution of Blue Force Combat Power over a Portion of the Combat Area at an Instant of Time

preparation for an attack, for example, most combat power will be distributed within the friendly force area.

A diagram similar to Figure 20 could be made for the spatial distribution of combat potential for the Blue force. A major difference would be that combat potential would be distributed only within the area occupied by the Blue force, since potential, by definition, does not involve actions against the enemy. Once combat is in full swing, most of available combat potential will normally have been converted to combat power.

The conceptually simple presentation of spatial distribution presented above is unfortunately belied by the complexity of real-life combat. There is not as yet any way to mathematically combine the combat power contributions of a mixed bag of processes, nor even to quantify completely the contributions of a single process. Hence it is not possible to produce a mapping like Figure 20 for a real combat situation, even though we can envision it. Yet commanders in combat, drawing on experience and training, intuitively accomplish the task of summing combat power and visualizing it in time and space. Superiority of one force over another is the result of skillful distribution of elements and actions that are decisive in space and time. Experienced command leadership and a high degree of combat readiness are essential for this to happen.

8.4.2.2 Distribution in time. The distribution of combat power in time is illustrated in Figures 21 and 22. Figure 21 shows distribution at the micro level for a relatively short time interval (t_1 to t_2) at a single point in space occupied by one Blue force object element. Each of the bars represents the combat power contribution from a single element-action-element activity with associated result during the interval. Combat power contributions from both Blue and Red forces are shown. Since the point is occupied by a Blue force element, the Red combat power contributions are from Red external processes and the Blue contributions are from Blue internal processes.

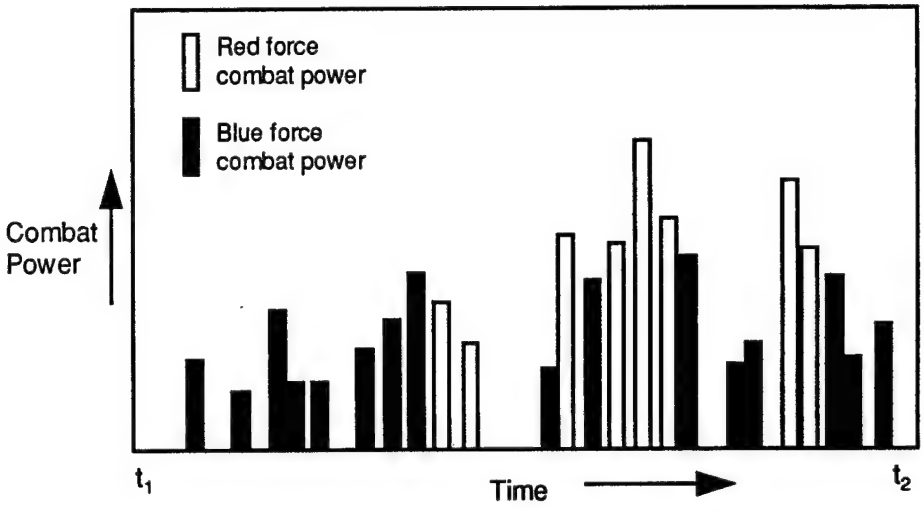


Figure 21. Micro-Level Distribution of Combat Power over Time at a Point Occupied by a Blue Force Object Element

Figure 22 extends the picture to show time distribution of combat power aggregated over an area within Blue force territory, the time interval here being from the initiation of combat (t_0) to its termination (t_t). The combat power aggregated in the figure could be that from all processes or it could be from just one combat process, such as destruction or suppression. The size of the area is small compared to the total area of combat, but is substantially larger than the single point of Figure 21, and so this representation approaches the overall view that combatants have of combat. Since the area is within Blue force territory, Red combat power from its external processes is sometimes great and sometimes negligible, whereas Blue combat power from its internal processes is spread more uniformly. Figure 22 is an aggregated smoothing out of the finite number of individual combat power contributions occurring in the area.

8.4.2.3 The vector aspect of combat power. Figures 20, 21 and 22 display combat power as if it were a scalar quantity without regard to its vector-like characteristic, yet the vectoring of combat is a powerful means of channeling

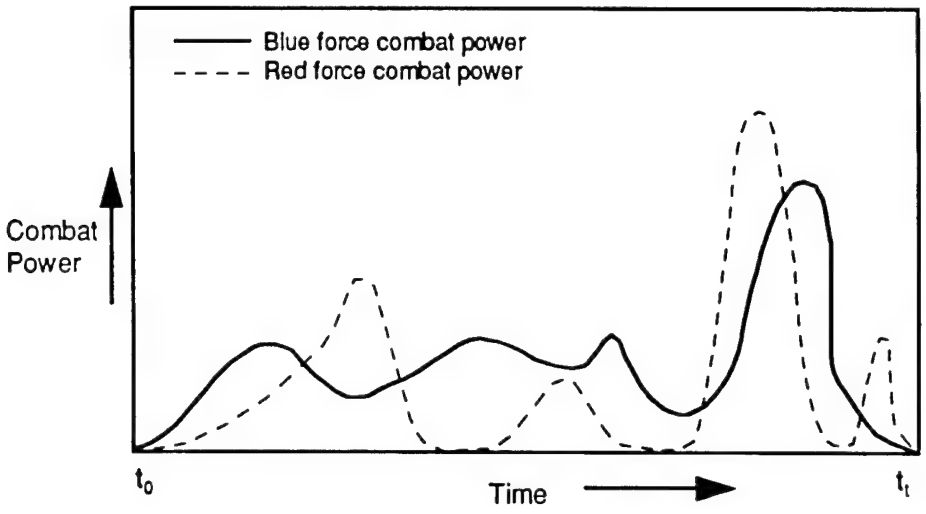


Figure 22. Overall Distribution of Combat Power over Time in an Area Occupied by Blue Force Elements

effort. The vectoring, however, while always intended to be favorable, is not always so in actuality, and so this negative aspect of distributing combat power must be examined.

The vector aspect of combat power is illustrated in Figures 23 and 24. Figure 23 presents vectored distribution of combat power within a portion of the combat area from the commencement of combat (t_0) to its end (t_t). The ordinate represents combat power that has been vectored to achieve desired results. Where the combat power has in fact resulted in changes of state momentarily

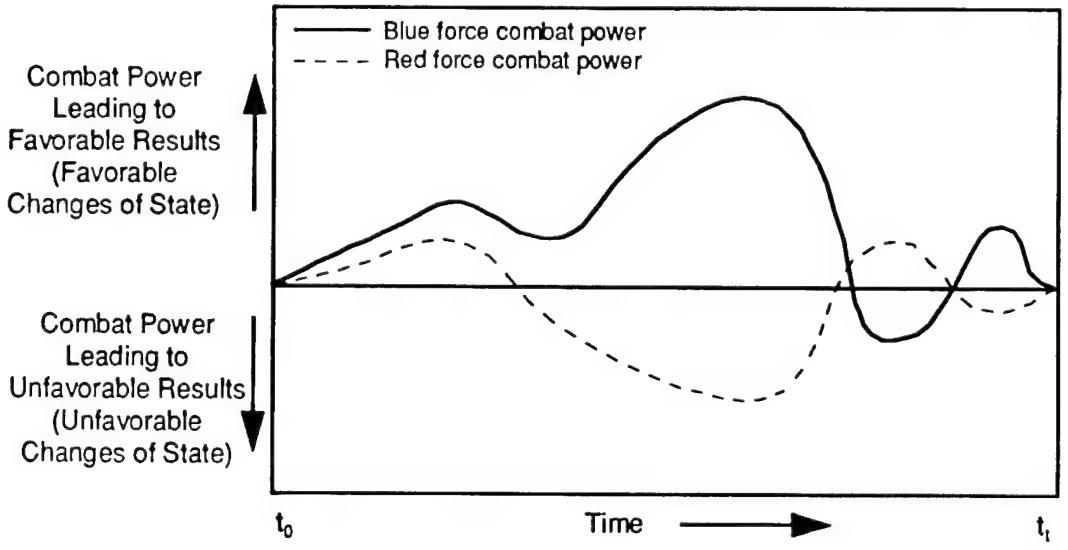


Figure 23. The Vector Aspect of Combat Power

favorable to mission accomplishment, it is plotted above the index line as a favorable vector. Where it has led to changes unfavorable to mission accomplishment, it is plotted as an unfavorable vector. As a simple example, when one side is advancing to take a hill, its combat power vector at that moment is favorable, but if the enemy forces a retreat, the vector has turned unfavorable. Many other factors besides advancing or retreating can, of course, affect the combat power vector, such as casualties being sustained compared to those inflicted on the enemy, orders being disseminated rapidly or not, and improving or diminishing fighting spirit. Since combat power is seen as rates of changes, its vector will be in terms of rates of advance or retreat, rates of casualties, rates of change of morale, and so forth.

In Figure 23, both Blue and Red experience periods of unfavorable state changes, the consequence of the combat power vector having been adverse. For each side in combat, favorableness or unfavorableness is generally inversely related to that of the other side, but there is not a one-for-one inverse correspondence either in space or time because the missions of the two sides are not necessarily in one-for-one direct opposition. In addition, there can be other reasons than enemy action for combat power being unfavorably vectored, such as errors, inefficiencies, and bad decisions on the part of the friendly force. In most such cases attributable to the friendly force, the fault does not lead to the vector being totally reversed, but rather to it being skewed away from full support of the mission. In the example cited above, a faulty judgment about the terrain might result in a slowing of the advance and thus a less favorable vectoring, but not a retreat.

8.4.2.4 The vector aspect of combat output. Combat output, the cumulative effect of combat power over time, is equivalent to combat work accomplished. As such, combat output is reflected in the cumulative results, favorable and unfavorable, which equate to the cumulative states of a force. Since output derives from combat power, it likewise has a vector-like characteristic, leading to the state of the force at times being favorable or unfavorable to mission accomplishment as combat progresses. The measures of combat output are largely in scalar quantitative terms such as cumulative amount of ground gained or lost, casualties inflicted on the enemy versus casualties sustained, and enemy aircraft shot down and ships damaged versus own-force losses. But combat output is also measured in factors less conducive to quantification, such as accumulation of intelligence information versus lack of it, retention of communication links versus loss of them, and increase in fighting spirit versus demoralization. As to both the more and the less quantifiable measures, the vector aspect for each adversary enters insofar as the cumulative measures are favorable or not to mission achievement. Ground may have been taken toward the mission objective, but if the cumulative costs in casualties, loss of unit

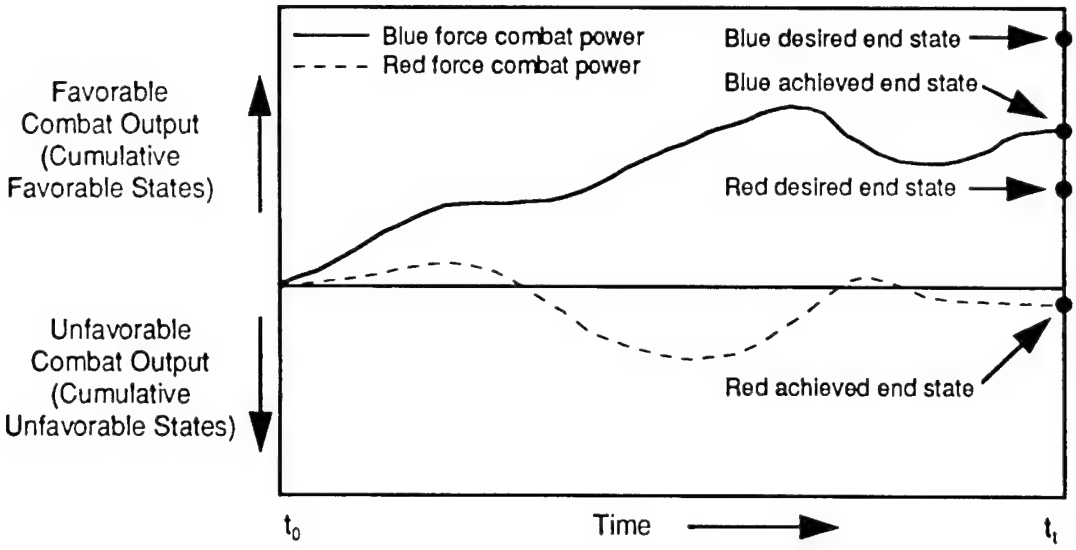


Figure 24. The Vector Aspect of Combat Output

integrity, and lower morale were excessive, ultimate mission fulfillment may have been set back, and combat output vectoring will have been unfavorable.

Figure 24 shows the changes in vectored combat output over a part of the combat area that follow from the combat power example of Figure 23. In Figure 23, the curves represent the time rate of change of state for each of the two sides. The combat output curves in Figure 24 are the integrals of the combat power curves in Figure 23—the cumulative states, favorable or unfavorable of each side. For Blue in the example, combat output is favorable to mission accomplishment throughout the duration of combat, although it becomes less favorable during the period when Blue combat power becomes unfavorable. For Red, there are periods when net combat output is unfavorable, and Red ends the combat action in such a state. As shown, neither Blue nor Red fully reaches the end-states each sought, but Red's shortfall is greater than Blue's.

8.4.3 Dynamics of Distributing Combat Power

The propitious distribution of combat power in time and space is a *sine qua non* for success in combat. Distribution in time and in space is carried out as a single integrated activity, but to facilitate presentation, each will be discussed separately.

8.4.3.1 Propitiousness as a measure of merit. For both time and space distribution, we use the notion of propitiousness instead of optimality as the measure of merit. Propitiousness involves a range of time and space over which results obtained are, as of that moment in the course of combat, observably favorable.

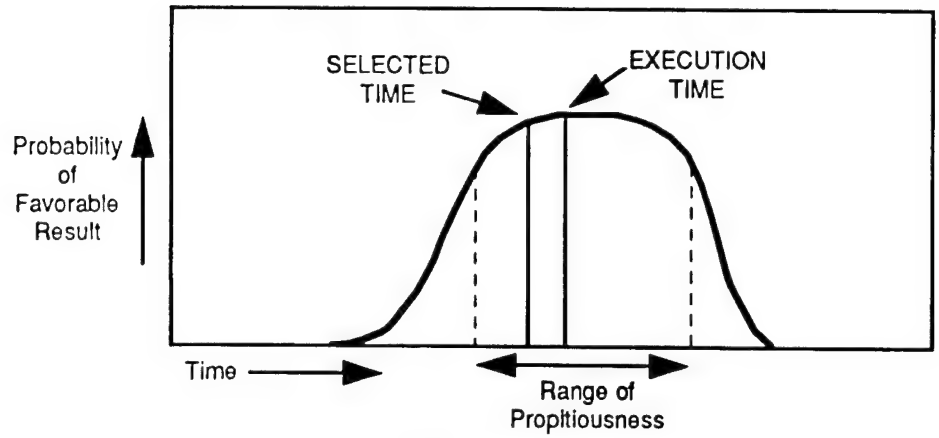
This is not retrenchment from rigor, but rather a recognition that at any time during the course of combat there cannot be an *a priori* optimum distribution of combat power, since such an optimum presumes foreknowledge of the future effects of enemy and friendly actions being taken, as well as of the ultimate outcome of combat. Combat cannot be presented as equations in closed form in which answers are predetermined when the input variables are known.

Time propitiousness is illustrated in the three cases shown in Figure 25. For each case, the time of actual execution lags behind the time of execution selected by the commander, a common occurrence in combat. In Case 1, the action is not time-critical, so the range of propitiousness is broad, and fortuitously, time of execution turns out better than the selected time. In Case 2, timing is sensitive and the time of execution falls outside the range of propitiousness. Case 3 shows an instance where time of completion is so critical as to constitute a firm cut-off; execution is so late there is no favorable result at all.

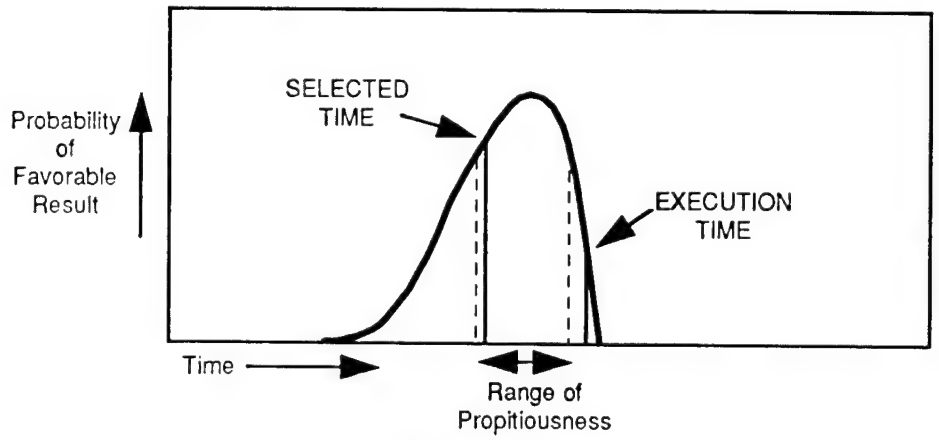
Extending the notion of propitiousness to distribution in both time and space becomes more difficult to visualize. Propitiousness in essence is captured in the dictum attributed to General Nathan Bedford Forrest of "getting there first with the most men." But sometimes getting there first even with less is propitious, and at other times getting there with the most even tardily is propitious. About the only ground rule that can be stated is that whatever falls within a range of advantageousness at the moment in light of the course of combat to that point is propitious.

Combat comprises innumerable such single-action degrees of time-space propitiousness or unpropitiousness. The result of every individual action can in principle be characterized by the propitiousness (or lack thereof) as to when and where the action occurred, and the aggregated time-space distribution of many actions can be viewed as propitious in the aggregate or not. The propitiousness of a single action can never depend on the merit of the action in isolation, but must depend on its contribution to the stream of actions there and elsewhere. In the eyes of participants, distribution in time and space (as with all aspects of combat) is viewed in the aggregate and will be seen more as art than science. The principles of war and operational manuals make clear the utmost importance of spatial and time distribution of the combined elements and actions of a force acting in concert.

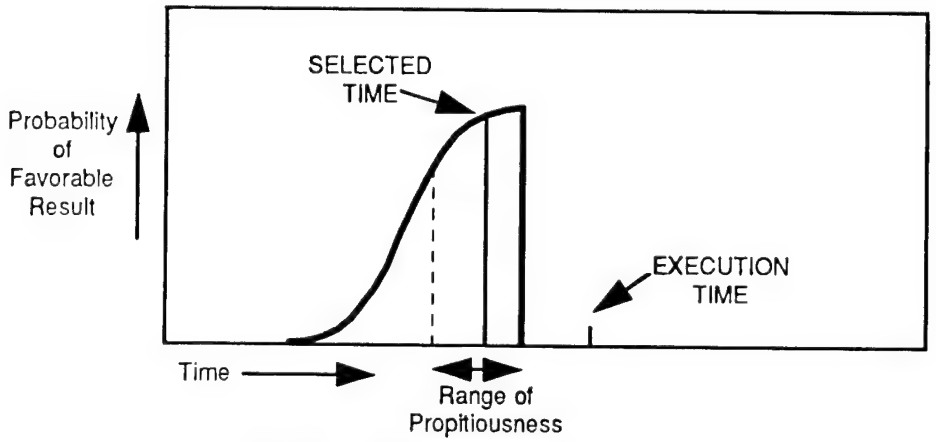
8.4.3.2 Information feedback loops and action-reaction cycles. Since combat involves two-sided force-on-force activity, there is a constant cycle of action and reaction and information feedback by both sides, some of it feedback regarding the friendly force and some about the enemy. Within his plan of actions, a commander will incorporate planned reactions to anticipated enemy initiatives



CASE 1 – Action is not time sensitive



CASE2 – Action is time sensitive



CASE 3 – Action is sensitive as to time of completion

Figure 25. Time Propitiousness

and counteractions, and both his initiative actions and his reactions will be modified as battle progresses. The outcome of combat will be critically affected by the timeliness of responses by the two sides in the action-reaction cycles. To make timely and propitious decisions, commanders depend on timely and high quality input information, and, of course, the efficacy of their decision-making also depends on how well they process that information.

Figure 26 depicts two information loops, one being the own-force loop that starts with own-force information acquisition, transmits information via intermediate nodes to commanders where decisions are made regarding further information acquisition, and then completes the loop back to own-force information acquisition. The other loop involves intelligence information, which is sent to the same commanders for decisions about further intelligence information gathering, and then back to intelligence acquisition. In both loops, communication links all nodes. The two loops operate in parallel and meet at the commander node, where both kinds of information are weighed to produce the outgoing directives for further acquisition and for other own-force actions (these latter actions are not part of the information loops; they are part of the action-reaction cycle). Although the decision node in Figure 26 shows commanders, the loops pertain not only to those in the command chain but to all individuals, since all contribute in some degree to decision-making.

The time it takes for information to cycle through the information loops is critical. Likewise, time responsiveness in the action-reaction cycles is critical. The side that can acquire, cycle, and process information faster and that can react faster to processed information has a great advantage. Figure 27 is a depiction that combines the information acquisition loops and the action-reaction cycle in the form of a horizontal double figure eight, one for the Blue force and one for the Red force. For each force, the length of time, starting from the commander node at the center of the figure eight, out along the information acquisition loop, back to the commander, then out along the action-reaction cycle, and finally back to the commander again, represents total time responsiveness for information gathering, information feedback, information processing, force reaction, and feedback of information about force reaction. The total time responsiveness is conceptually the sum of the two cycles (the total path along the figure eight). In the Blue force versus Red force comparison illustrated in Figure 27, Blue is shown as having the longer information acquisition cycle time and the shorter reaction cycle time.

Within the commander node at the center of the figure eight, information (as perceived) is continually being received, integrated, stored, and processed periodically into orders in reaction to the situation. Information about the

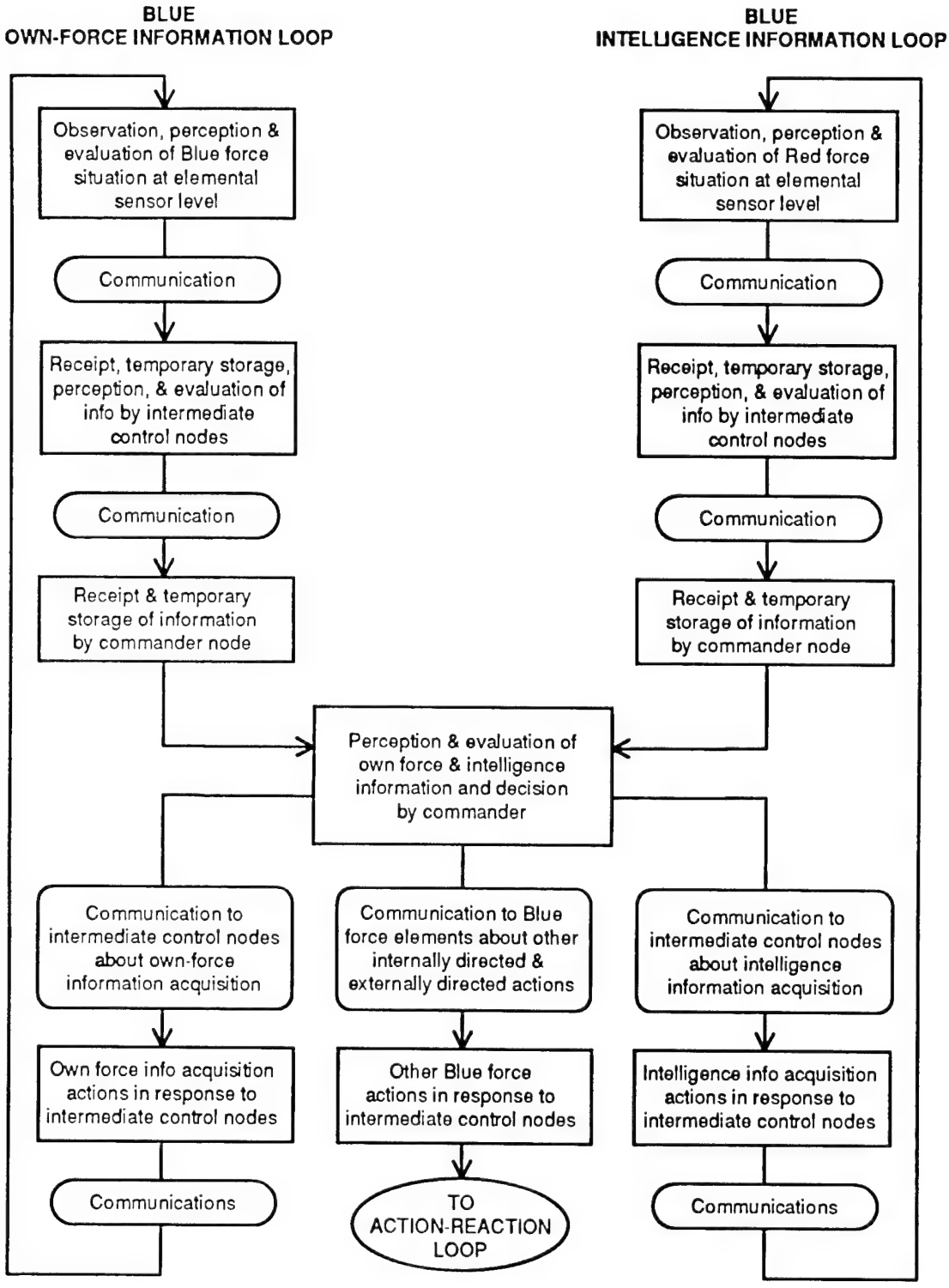


Figure 26. Information Processing Loops

reactions is then returned to the commander, where it is again integrated, stored, and processed for further decisions about information acquisition and force action.

For actual combat, the concept of time responsiveness illustrated in Figure 27 is not possible to reproduce quantitatively, since the flow of information is continuous at and between all nodes, with continual mixing of information at every node. In addition, information is subject to storage for varying periods of time and is retrieved and processed sporadically. All of this makes for blended information melded from many discrete initial acquisitions in the manner of a stream accumulating flow from many rivulets. Overlapping and mixing obscures calculation of discrete time lags. Nevertheless, in principle, an element of information could be traced through the system, and the transit time measured. Regardless of the doubtful practicality of accomplishing this, it is crucial to minimize time lags.

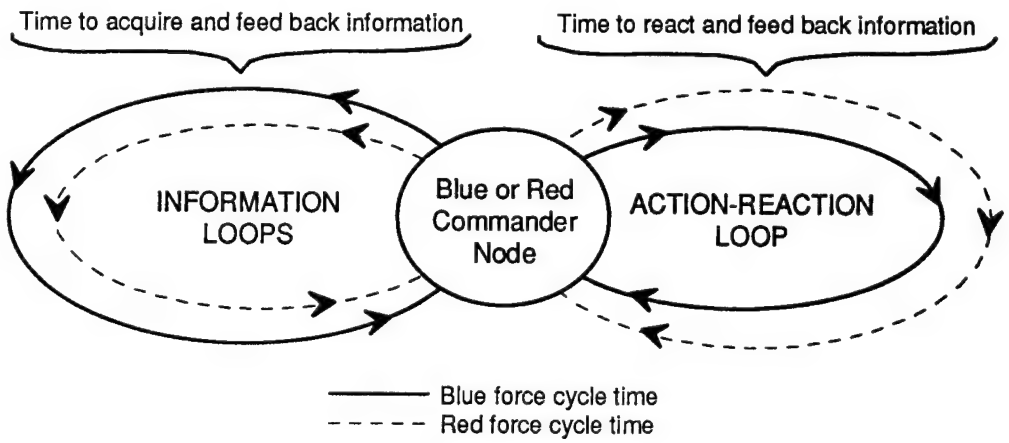


Figure 27. Combined Information and Force Reaction Time Cycles

What counts, of course, is not merely less time lag in absolute terms, but less lag than the opponent. The combat power advantage of one side over the other will be some function of the time lag differential. The effect is analogous to the advantage of one aircraft carrier over another by virtue of its quicker intelligence acquisition and its shorter turn-around time for refueling and rearming aircraft.

As mentioned previously, there is also a qualitative factor that affects the information loops. Information flowing through these loops is not the reality of the situation, but the perception of reality as conditioned by gaps and other faults in information gathering (about both the friendly force and the enemy) and in communicating. These shortcomings are inherent in both information loops, but are especially critical in the intelligence loop. The qualitative aspects of information flow are as important as time lags.

8.4.3.3 Achieving propitious distribution of combat power. There are no standard formulas to guide commanders in distributing combat power. No two missions are the same, no two situations are exactly alike, and the number of factors to be taken into account is immense. General guidelines are found in the principles and maxims of war. More specific guidelines exist in doctrinal and tactical manuals, training courses, military history, and most important, the hard lessons of combat experience. To these can be added the universally accepted dictums to focus combat power so as to exploit enemy weaknesses, use surprise and shock effect, concentrate force against the enemy's decisive sources of strength and balance (his center of gravity), take account of culminating points during operations, and observe other time-honored precepts. Implicit in all these guidelines is the advantage accruing to the side that has the more rapid and more effective responsiveness.

8.5 THE FLOW OF COMBAT

8.5.1 Trends and Projections

The high value placed on combat outcome compels continuing assessment of where the action is leading. At all times in battle, commanders and all others observe events and interpret them as trends—own-force losses versus enemy losses, strong points gained or given up, units holding or disintegrating, progress toward mission achievement versus shortfalls. Each combatant projects the observed trends as adverse or favorable to him, his unit, and his cause and is influenced in his actions by the projections. When combat appears to flow smoothly, the projections generally appear to have a comfortable degree of certainty. When combat appears to be chaotic, the future seems less certain and the actions that should be taken less clear.

8.5.2 Actual Versus Perceived Trends

With trends we must once again distinguish the real from the perceived. A multiplicity of actual trends is at play at any moment in combat. Sometimes the trends are strong, widespread, and reinforcing. At other times the trends are weak, localized, and disparate. In either case, actual trends derive from the flow of actual events. They exist in reality.

Perceived trends, on the other hand, are derived from information acquired about events, and are subject to all the numerous faults of the acquisition process plus the overlay of subjective interpretation during the multilayered command and control functions. Perception may miss an actual trend until it has gotten out of hand, or conversely, may grossly exaggerate a trend of little real importance.

In any case, events are passed through the filter of perception and it is trends as perceived that continually form the basis for each combatant's projection of the future. Perceptions by individuals are not reached independently; they are influenced by the perceptions of peers and superiors, particularly commanders. Thus, while the perception of trends is an important influence on each individual, these perceptions take on a group coloration in much the same way that cohesion and disjunction infectiously modify group behavior.

Much investigation has been carried out on the effects of trends upon the outcome of combat. A major focus of this has been investigation of mathematical models that represent trends, much of the work concentrating on attrition equations and their many variants, such as versions of Lanchester equations. Often, the models indicate a trend that continues inevitably in the same direction to some point taken as defeat or exhaustion or unit break point. In other cases, solutions may terminate in one or more equilibrium points that act somewhat like the attractors of chaos theory. All these mathematical representations of combat are recognized as gross simplifications of reality.

Nevertheless, the question may be asked whether there are real trends in combat that, once begun, continue inexorably in the same direction. Consideration of a wide variety of trends (for example, in ground gained or lost, motivation or demoralization, cohesion or disjunction, rate of casualties, losses of materiel) leads to the conclusion that the only real trends that might be classed as inevitable and irreversible are those dictated by the process of destruction. Other trends appear to be subject to reversal, given the right conditions. Indeed, this is the basis of culminating points in land combat doctrine. One reason lies in the action-reaction cycles, where perceptions of adverse trends continuously lead to attempts to alter the trends, with at least occasional success. A more significant reason probably lies deeper, involving human behavior and the power of combat units to self-regenerate and self-reorganize.

Destruction can be considered as not subject to reversibility because once an object is destroyed, it ceases to exist and cannot be resurrected. The point, however, is only partly valid, and somewhat trivial, because some losses can be replaced during combat and some damaged materiel and wounded combatants can be restored to battle.

Although trends of real events do not appear to proceed inevitably, perceived trends nevertheless have a pronounced effect on the outcome of combat. In accordance with Axiom 5, the perception by one side that it is achieving domination or by the other side that it is becoming dominated has a powerful cognitive effect that is often self-reinforcing.

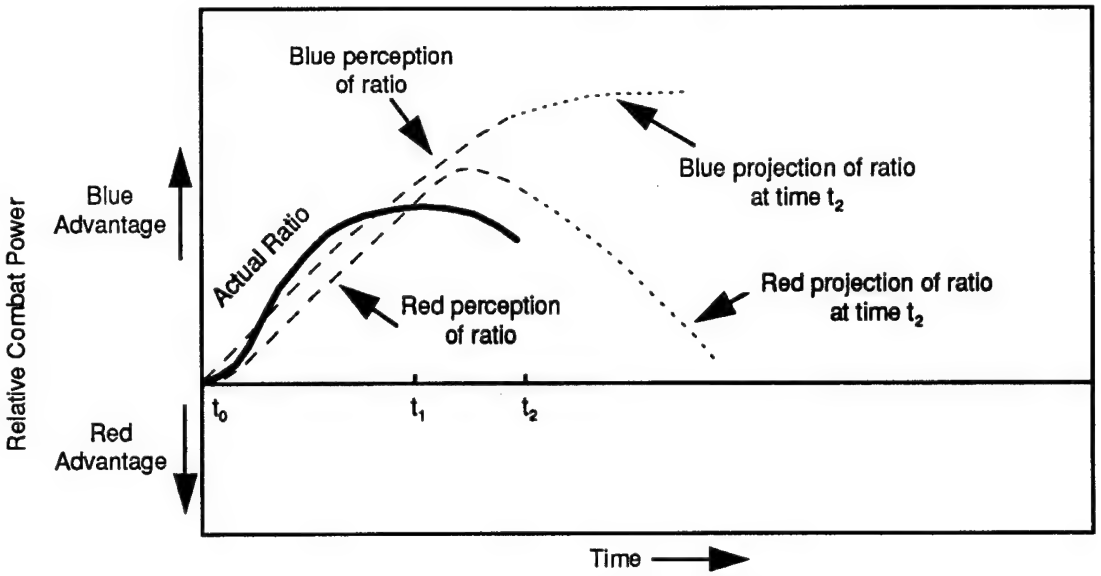
8.5.3 Projections of Perceived Trends

It is the projection of perceived trends more than the trends themselves that governs decisions about future actions. This applies at all decision nodes from individuals to the combat commander. A commander who projects that a pattern of events will lead to future trouble will seek to turn the unfavorable pattern to a favorable one, or if unable to do so, may try to disengage from combat. An individual soldier may seek to improve his projected future, or in the extreme, may become disheartened and lose his will to fight. Disparate projections from mixed trends can dissipate combat power in friction.

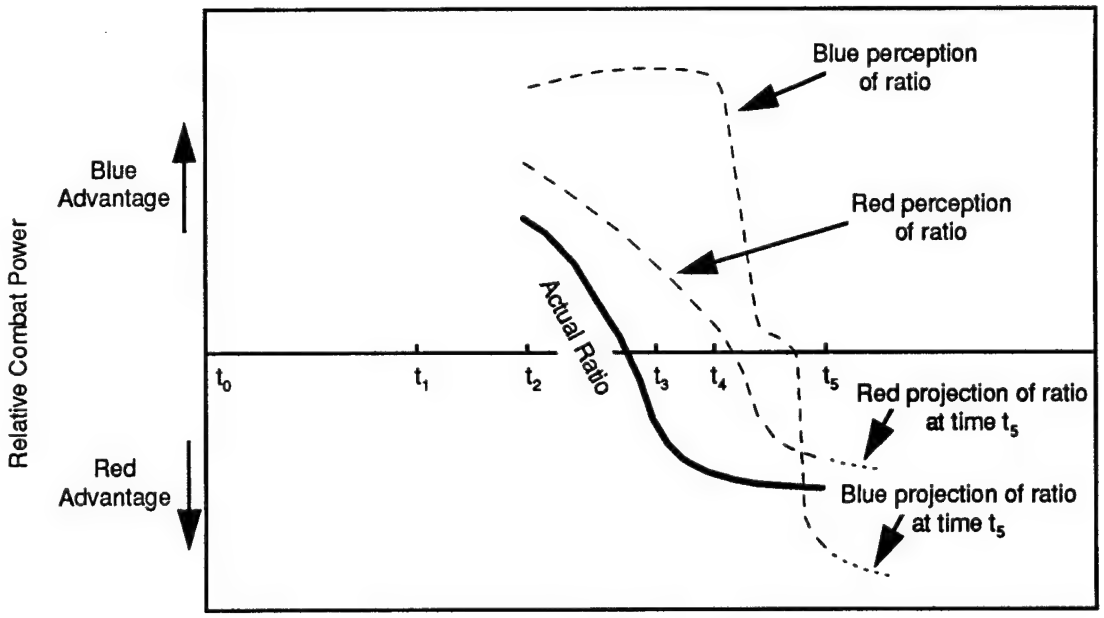
Because commanders are aware of time lags and faults in information acquisition and the command and control functions, projected trends based on perceived events are susceptible to exaggeration and overcompensation in decision-making. The decision mechanism acts sometimes like a servo system in which imperfect responsiveness results in sometimes overcontrolling, sometimes undercontrolling, and sometimes oscillating between two positions. Poor time responsiveness amplifies the overcontrolling and undercontrolling.

Figure 28 illustrates the effect. The figure plots the actual and the perceived ratio of combat power of the two sides. Combat begins at time t_0 with an attack by Blue and has proceeded to time t_2 in the upper figure (28a). The actual relative combat power initially favors Blue, but begins to be less advantageous to Blue at t_1. By time t_2, Red has noted the trend reversal and is projecting a trend that will ultimately turn in his favor. Meanwhile, Blue has not perceived the trend reversal and continues to project a trend increasingly favorable to him. Figure 28b shows events from time t_2 to t_5. At time t_3, Red, acting on his trend projection, initiates a forceful action to capitalize on the changing situation. Blue's perception (and hence his projection) continues to lag until time t_4, when his perception finally catches up with the now drastically altered situation. Blue finds himself in the position of the cartoon character who has run past the edge of the cliff and, legs still churning, belatedly looks down, then falls. By time t_5, Blue is again overreacting by projecting a catastrophically unfavorable trend, thereby fulfilling his own excessive projection. Blue's fault lies in too-slow time responsiveness in acquiring and processing information. Red's faster responsiveness gives him a substantial advantage.

Figure 28 also illustrates the importance in trend projection of recognizing a culminating point in combat. A culminating point occurs when the combat power of an attacking force no longer significantly exceeds that of the defending force. At a culminating point, the attacker should shift to the defensive. In the example, the culminating point occurs somewhere between t_2 and t_3. At time t_2,



a. Combat from Time t_0 to t_2



b. Combat from Time t_2 to t_5

Figure 28. Effect of Erroneous Projection of a Perceived Trend

events are such that Red has perceived that a culminating point may be approaching and is acting accordingly. Blue, not anticipating the culminating point, is not only not in no position to delay or negate the culminating point but, worse, continues to take actions that eventually lead to his catastrophic failure.

As noted in the U.S. Army Field Manual 100-5, *Operations*, commanders must understand that in battle, men and units are more likely to fail catastrophically than gradually. Figure 28 depicts the catastrophic failure from delayed perception and consequent erroneous projection by Blue of an adverse trend, as distinguished from the timely and correct perception and projection by Red of a trend favorable to him. Military doctrine universally emphasizes the paramount importance of perceiving and exploiting trends toward failure by the enemy and mitigating trends toward own-force failure. Failing to exploit or to mitigate a trend when it is in a commander's power to do so is an egregious error.

8.5.4 The Episodic Flow of Combat

The flow of combat is normally episodic. The constantly shifting distribution of combat power leads to crescendos of violent action often followed by lulls. There is no repeatable pattern to this characteristic. Sometimes there is only a single crescendo, sometimes many spaced over time, sometimes two or more at once. A crescendo may arise from a sudden surprise engagement, or from a gradual build-up of action. A maneuver may cause a peak in the action, or sometimes firepower; more often it is both. The action-reaction cycles tend to give a cyclic character to the peaking and ebbing of combat power, a sort of pulsing of activity. Action-reaction cycles at the macro level are, of course, composed of myriads of micro action-reaction cycles, and it is the vectored reinforcing of these that gives rise to this pulsing of activity. But here again, there is no repeatable pattern, no consistency from one combat situation to another.

In some ways the episodic flow of combat can be compared to the flow of a turbulent stream, with its mix of smoothly flowing water and occasional rapids and whirlpools. The comparison is apt because describing turbulence in liquid flow remains an unsolved problem in physics; there is as yet no adequate theoretical basis to take account of whorls and eddies, or even how turbulent flow begins. Similarly, in combat we are limited in how far we can go in presenting a theoretical basis for combat dynamics. One of the tools applied in an attempt to cope with turbulence in liquid flow is the concept of state space (also called phase space), a conceptual space where each dimension corresponds to one variable of the system. But in combat, there is no discernible periodicity in the way the variables behave, and there are so many variables as to render an approach using state space meaningless. In the extreme, the number of variables

equals the number of individuals engaged in combat (plus the combat environment variables), and the state space spreads out in uncountable dimensions.

To recognize that combat is turbulent, in the sense of being generally episodic with intense combat power pulses and lulls, is not to say that at present we can scientifically do much about this characteristic. Yet commanders can and do cope with the turbulent flow of combat. Where the scientist sees random, unpredictable, formlessness in the turbulence of a river, the commander sees useful patterns in the flow of human actions during combat. And others under the commander likewise see patterns that enable the force as a whole to cope with turbulence and chaos and make sense out of combat. A unit in combat thus draws order from a sea of chaos. As the eminent scientist Erwin Schrödinger put it, a living organism has the "astonishing gift of concentrating a stream of order on itself and thus escaping the decay into chaos."

8.6 A BEGINNING

Combat, perhaps the most complex of all human endeavors, is certainly one of the most trying. The nature of combat, with its uncertainties and its peaks and lulls, with combat power constantly being changed in a three-sided mix, and with its human behavioral unknowables, follows no repeatable pattern that allows for predictability in detail. Despite this, trained commanders and forces find ways to successfully apply combat power and achieve missions. Where many throw up their hands at the complexity and turbulence of combat, the ones called on to wage battles make a creditable showing of it. In the same vein, where some disparage as hopeless an attempt to explain the intricacies of combat with any useful validity, we in this document have at least tried. If nothing else, this is a beginning.

Chapter 9

COMBAT THEORY AND ITS CONTINUING EVOLUTION

9.1 GENERAL

In the foregoing chapters of this document, we have presented a military combat theory. We have defined the role of combat within the spectrum of conflict and then developed a comprehensive description of combat in the form of a metamodel. The development relates combat to broader sociological variables. It ties combat to mission. It addresses the components of combat as elements, attributes, actions and activities and from there to the functions and processes of combat. It describes the dynamic nature of combat structure and the complexity of component interactions within the structure. The results of these interactions are described in well-defined operational terms such as combat power, friction, surprise and uncertainty.

Nineteen years ago at this writing, in the meeting at Leesburg, VA, the need was stressed for stronger scientific underpinnings to ongoing work in warfare modeling and simulation. This meeting and the chain of events that followed have resulted in the present concise theory. While the Leesburg conference focused on modeling at the theater level, the meeting's proceedings and summary volumes called for theory development more appropriate to a broader context of war in general, and modeling in particular.

Careful, disciplined investigation of the problem over the intervening years has led us to define combat as the kernel of all manner and means of war. In detail and in depth, the description of combat in the concise theory goes well beyond existing modeling. Thus, the theory exposes modeling problems related to the analysis of real warfare that are even more difficult to deal with than anyone suspected at the time of the Leesburg meeting and which remain with us to this day.

There may be other ways of portraying combat in all of its complexity. Regardless of the form taken by such alternative views of combat, it is important that they accommodate all observable aspects of its phenomena. Therefore, they should demonstrate some measure of feature-by-feature conformance with the steps identified in the methodology of this document.

Clearly, significant tasks lie ahead if we are eventually to claim useful, "proven" theoretical constructs in keeping with the aspirations of the Leesburg conference

and TMCI charter. These tasks can be characterized by their orientation toward theory application, validation, or theory extension, recognizing that these factors are somewhat interdependent. The remainder of the chapter is devoted to discussion of the role each plays in the refinement and evolution of the combat theory.

9.2 UTILITY AND APPLICATION OF COMBAT THEORY

The purpose of a theory of any complex phenomenon is to gain the most complete and clearest understanding of its processes, while striving to collect and present the information in a structured way. The understanding of a phenomenon as complicated as military combat leads to an ability to identify and measure the results of interactions among its internal workings. Theory maintains a broad, all-encompassing (and hence higher) position on the hierarchical ladder of knowledge, and it is the existence of theory that guides the scientific development of models. There are variables and processes identified in combat theory that defy modeling efforts. The very existence of theory, extending beyond the narrower scope of modeling, provides a clearer picture of how well the problem is understood.

No such comprehensive understanding of combat has existed. From very early days, military theorists such as Sun Tzu, von Clausewitz, Jomini, and Mahan have contributed essays to the large body of knowledge concerning armed conflict. Their efforts created the foundation for combat theory. The present effort attempts to address a part of the problem through application of the scientific method that has the rigor and consistency to afford a more comprehensive view of the entire process. Most particularly, it sheds light on the simultaneity of all combat activities, and the role of combat within the total conflict spectrum.

Combat theory should be of prime importance to several classes of military and civilian users. These would include military practitioners (operational commanders, staffs, planners); training professionals (basic and advanced training, unit training, exercises, special schools); and military thinkers (developers of tactics and doctrine, designers of operational tests, faculties and staffs at military academies, universities and war colleges, military research institutes, developmental activities). Other users should include the civilian defense analysis community (academic institutions, contract researchers, not-for-profit think-tanks, historians, military buffs); and the modeling community (military modelers, civilian modelers, entertainment modelers and game developers).

Several military tasks can be well served by applications of combat theory:

- Basic education of personnel in military science
- Development of mathematical models and simulations of combat
- Historical reconstruction and analysis of combat and war
- Formulation of operational concepts and strategy
- Doctrine development
- Development of military weapons and support systems
- Development of force concepts, structures, and organization of forces
- Design of military exercises and combat experiments
- Battle management and warfare analysis in real time

Reliable theory offers advantages that extend well beyond the focus on particular aspects of combat and the ability to quantify. Theory that provides extensive mapping of all of combat's parts into its whole affords an overview for military commanders, planners, students and historians alike of combat's unusual structural and dynamic complexity.

When interest centers on processes that are more cognitive, such as command-control, motivation, and information acquisition, the utility of sound theory increases. Such processes are difficult to study and model explicitly, even though they pervade combat. Knowledge of how and where they enter the picture can be very useful even when their full effects are not understood. Theory that establishes patterns of influence and dependence among the combat processes would give military thinkers a deeper understanding. As a result, it plays a subliminal but important role in matters of tactics and doctrine, force structuring, and designing field exercises and tests. When attention shifts to actual military operations, combat theory becomes a source of foundational knowledge. In these latter instances, ties between theory and the real world are largely non-explicit and subtle. Nevertheless, the deeper understanding of combat provided by theory can contribute to military thought and practice.

What is of greatest significance for the Leesburg meeting is that its primary recommendation has finally been addressed. A theory of combat has been developed for testing, modification, and improvement through widespread application to military problems, general validation using a variety of schemes, and further extension through research into broader areas of conflict such as campaigns and wars.

9.3 VALIDATION OF COMBAT THEORY

In testing combat theory, we must compare key aspects of the theory against evidence from the real world. Our theory comes almost entirely from a distillate of human experience over much of recorded history. However, since World War II, the subject has taken on a more scientific cast that reflects attempts to apply mathematical and computational techniques to the study of combat.

The present theory undertakes the task of describing all facets of combat in their interactive intricacy. Models address the degree of this interactivity over some restricted region of the theory domain. They generally strive to attain a higher level of information but over some narrower band of interest. While our theory is descriptive, a shift to modeling introduces possibilities of predictive investigation. Yet the validation requirements for models with prescriptive and predictive power are far more formidable than those for the descriptive theory we have presented here.

Existing data to use in theory validation is abundant but is hardly ever in a form that is immediately and directly useful. Generally, we must ferret out the information we need in a process that is both protracted and difficult. There are experiments and exercises that can be performed in direct response to a need for specific data and information, but relatively little of this form of activity has been undertaken to date in keeping with the general lack of attention to anything like combat theory and its validation.

Because combat theory comes from combat experience, validation consists of comparing theory against instances of combat drawn from military literature, history, and experiment. Evidence likely to be useful for theory validation includes:

- Natural experiments recorded in
  - Military histories
  - Memoirs of military notables
  - Essays and treatises in military theory and science
- Purpose-built experiments such as
  - Combat exercises and experiments
  - Investigations of human behavior under stress
  - On-going warfare experimentation
  - Models and simulations of combat

We find that the natural experiments offer the most prevalent and voluminous material, generally in narrative form as books, journals, articles, and professional papers. These provide data for what might be termed "soft validation," a process that aims to corroborate the universality of our theory's structural boundaries.

Included under such efforts are the following postulated characteristics of theory to be checked:

- Universality over time from antiquity into the future
- Invariance with combat domain (land, sea, air, and space)
- Invariance with combat scale and intensity over the conflict spectrum
- Structural congruity throughout the hierarchy of forces
- Structural symmetry for opposing forces

Additional aspects of theory that may be amenable to soft validation are:

- Individual and unit behavior in combat
- Combat friction, combined arms synergy, force integrity, and cohesion
- Episodic nature of combat
- Influence of external context variables on combat

Soft validation might proceed from an extensive sampling of accounts of historical military actions that involve land, sea, air or combined arms combat. The sampling should also extend over time from antiquity to the present and should vary in combat scope from limited to large scale activity. Working with a rich enough set of historical evidence will permit partial corroboration or modification of the theory aspects listed above. To do so will first require that we attempt to trace function and process flows defined by theory through the historical accounts of combat. The entire structure of combat postulated in the theory should be carefully analyzed for satisfactory piece-by-piece fit with historical accounts that have been selected.

When steps in theory development are so basic or abstract as to fall outside the purview of historical narrative, as with the axioms of Chapter 2, we can make use of "nonfalsification" principles in seeking a form of soft validation. This means that instead of seeking evidence of a match between theory and reality, we content ourselves with an apparent absence of any evidence that such a match does not exist. This is an even softer approach to validation, but at times it may be the only option.

As we take our theory through combat structure (Chapter 6) and into structural dynamics and combat power (Chapters 7 and 8), we close in on the need for hard validation to couple theory to reality. Hard validation will demand models, exercises and experiments. As we push more deeply into the dynamic interactivity of combat variables, qualitative descriptions of the phenomena are no longer adequate. Instead, we are driven to measuring degrees of interaction in some way. This enables us to confirm meaningful theoretical relationships as, for example, between combat power and its sources. Samples of such relationships are hypothesized in Chapter 8 in figures and plots (see Figures 23 – 25) that

should be exposed to testing. However, hard validation exercises cannot be based on historical material or essays. Instead, special experiments must be designed and the use of mathematical and computational models explored. Data gathering must be tailored to validation needs in specific yet complex areas of combat theory.

Hard validation will be difficult, and a long, complex, multifaceted effort. It appears that the best chance for success is afforded by iterative, adaptive, self-correcting interplay among the key factors as stated in combat theories, historical data, military thought, models and experiments, whether exercised sequentially or in parallel. There is a paradox, however. We must use models to help us validate theory, but we must have theory to help us construct proper models. An iterative procedure cycling between better theory and better validation techniques may well provide the interplay for theory evolution. An ultimate aim would be to take theory from its descriptive state through to prescription and prediction while at the same time providing for improvements in modeling. When we consider the combat dynamics of the theory we must start thinking in quantitative terms (hence modeling) in order to couple theory with the evidence of real world behavior.

The attainment of such coupling evades our grasp because of the inability to model all the combat processes that are involved. Military and operations analysts must carefully study the form of recent investigations undertaken in the physical, biological and social sciences that come under umbrella terms such as chaos theory, catastrophe theory, complex adaptive systems, fuzzy logic, neural nets and artificial intelligence. These new arrivals augment earlier investigations, such as those from game theory. At the outset, the adaptation of some of these for the study of military affairs may be as analogies or metaphors. Yet one would hope that when applied to analogous problems, these new scientific tools will provide us with useful descriptions of military phenomena. There is no real convergence of opinion as to the military applicability of these new techniques, even among the small body of experts in the field. It is quite possible that some or all of the new tools now being investigated may someday provide important advances to the theory of combat. At least these tools may aid in understanding combat through new relationships. For instance, the conclusion of complexity theory that progress and growth are most likely to occur at the boundary between a tightly ordered system and a chaotic, disordered system seems an insight full of meaning for military organization, doctrine and tactics.

Combat exercises and experiments as sources of validation data are generally activities conducted in a mock-warfare environment expressly to train troops, to develop tactics and doctrine, or to learn more about the technical and operational characteristics of combat systems hardware. Precious few experiments have ever been conducted for the purpose of validating models or

theories. If validation needs are to be met, they must be piggy-backed onto exercises and experiments designed for other purposes. Since exercises are relatively elaborate undertakings, they would be considered very costly and cumbersome were they to be used only for theory and model validation or accreditation. Since they involve range facilities with special measuring equipment and employ a variety of personnel, sensors, weapons and other military hardware representing both friendly and enemy forces, it is not surprising that experiment reproducibility and control of combat variables would be considered poor for validation. Yet there are recent trends toward the selective conduct of experiments that are designed for, and can be run in parallel with, certain model constructs and abstractions. Such efforts could contribute to validation.

A special class of experimental activity is laboratory and combat experiments designed to measure human performance under battle stress. This form of experimentation is a recent development that will play forces up to division and corps size, as well as joint task forces. It is too early to predict the degree of assistance these efforts will provide in testing combat theory. That they are being planned, however, is an indication of the importance attached to behavioral research in furthering a basic understanding of warfare.

On-going warfare as "the laboratory" is not a new idea. The scientific study of war began during World War II and eventually provided impetus to the establishment of operations research as a formal discipline. The early emphasis was on evaluation of system concepts and tactical hypotheses. Subsequent wars (including Desert Storm) have seen more elaborate and extensive analytical testing during the conduct of military operations. Yet actual warfare presents only fleeting opportunity for scientific observations and collection of data. Combat events are not under the control of the experimenters. Nonetheless, war provides an environment that cannot be surpassed for realism of battle data.

In summarizing the problems of theory validation, it is clear that uncovering data for hard validation will be more difficult than for soft validation. This condition is partially offset by the time-consuming process of sifting through mountains of soft data to find the right kind in the right form. Hard validation will become increasingly important as we become more concerned with measurement of cause and effect relationships. An adaptive procedure iteratively testing theory against varied sources of soft historical and hard experimental data appears to offer the most promising approach to theory validation. With little doubt, the road to validation will be long and difficult.

9.4 THEORY EVOLUTION

We believe that the concise theory of combat presented in this document satisfies the most urgent requirements. Beyond providing a comprehensive picture of combat, the present theory affords the means to examine both operations and analytical techniques as to their adequacy.

We recognize that there appears to be heavy emphasis on land warfare in the discussion and examples presented in this document. This is predicated on the belief that the complexity of land warfare exceeds that of other warfare domains and therefore warrants closer attention. While applicability of the theory to these other domains should not be in doubt, it nevertheless is fitting to look more closely into sea and air combat and to confirm their conformance to the theory as presented.

What has been presented in this document is only a beginning. Much remains to be done to broaden the present work by extending its scope throughout the conflict spectrum and furthering its depth of penetration into cause and effect relationships. Meanwhile work continues at the Military Conflict Institute on other forms of military conflict and we anticipate additional discussion from Institute members and from the public at large in response to this document. The theory of combat will evolve. At its best, this is only one step in a protracted process.

INDEX